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the Petroleum Engineer

FOR MANAGEMENT

DEC 1960

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THE PETROLEUM Engineer

FOR MANAGEMENT

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at presstime ... *a last minute round-up of petroleum industry news*

Refinery margins in October remained at the highest point in more than 1½ years. Independent Petroleum Association of America statistics show refineries received an average of $3.95 per bbl for petroleum products and paid an average of $3 a bbl for crude oil, providing a margin of 95 cents per bbl, unchanged from September.

Fewer employees are now needed to operate U. S. oil pipelines, Interstate Commerce Commission statistics reveal. In 1953, there were 20 employees per 100 miles of line. In 1959, this had declined to 15. Compensation increased, however. Operating personnel averaged $6,898.32 per year in 1959 compared with $5,278.96 in 1953.

Sale for $14,800,000 cash of producing properties belonging to Felmont Petroleum Corporation may be made to Cities Service Oil Company. This would include all properties in the United States and Canada except those located in the Gulf of Mexico and the Appalachian basin area. A special meeting of Felmont shareholders is scheduled this month for final approval of the transaction.

Contractors' accident frequency rate continues on a downward trend. Latest figures released by the Pipe Line Contractors Association show a frequency rate of 38.32, a decline from the previous month's 39.80. Last year's rate was 43.98.

The petroleum refining industry has not waited for insurance underwriters or government to force it into better control over explosions, but has taken the initiative itself. C. Henry Austin and J. C. Ducummon of Standard Oil Co. (Indiana), who addressed the API refining division's annual meeting in Chicago, agreed refinery detonations can be eliminated if hydrocarbons are not mixed with air in pressure vessels or lines except under rigorously controlled conditions.

How FPC will treat pricewise production by pipeline companies is still an undecided issue. Pipelines maintain they should be treated like any other producer and receive area prices for their gas. FPC Chairman Jerome Kuykendall also has expressed this view, but officially no ruling has been announced, and there are some statements in the Phillips decision that give rise to concern.

Ohio Oil Company has acquired all Kinney-Coastal Oil Company properties for $1,629,000 cash plus an oil and gas production payment of $7,300,000. Production payment will extend over about seven years. Kinney-Coastal net production amounts to about 2300 bbl of oil daily, mostly from the Garland Field in the Big Horn basin of Wyoming. Ohio Oil is co-owner of the field and has served as operator.

A new record peak of daily sales at 543 million cubic feet was established by Trans-Canada Pipe Lines, James W. Kerr, president, announced. The peak day at the beginning of the heating season a year ago was 286 million cubic feet. Average daily sales are now running well over 500 million feet: Total sales for the past twelve months have been 70% ahead of the 1958-59 period.

Northern Ireland's first refinery will be constructed at Belfast by British Petroleum Co. The $22,400,000 plant, to produce gasoline, kerosine, aviation turbine fuels, light and heavy diesel oils, fuel oil, and LPG, will have initial capacity of 30,000 bbl per day.

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highlights *and footnotes of the news*

API should reorient its objectives to take in world oil instead of serving only domestic interests, was suggestion of President Frank M. Porter. He noted that America's share of world oil reserves had dropped from 32 in 1945 to 11% although domestic reserves had increased.

Six times faster is the new IBM 7090 transistorized electronic computer. One is being installed in Socony Mobil's computer center in New York and another in Standard Oil of California's San Francisco headquarters. Previous applications of the 7090 have been limited to defense and space projects.

The radical Indonesian government has proposed a mining law which would place all oil operations under State control. If the law is enacted Caltex, Standard-Vacuum and Shell could lose their concessions.

After nearly 39 years in business Anderson-Prichard will sell its assets for $123 million. Producing and exploration properties will be sold to Union Texas Natural Gas, Houston, 5/6ths and Frankfort Oil, 1/6th. Refining, marketing and transportation properties were acquired by a new corporation, Apco, which will be managed by Anderson-Prichard officers.

Cities Service, which has taken over Arkansas Fuel Oil, is putting into operation a consolidation plan for domestic oil exploration, and production with headquarters in Bartlesville. Robert L. Kidd, now president of this operating subsidiary, will become chairman and will continue as chief executive officer. J. E. Heston, president of Arkansas Fuel Oil, will continue in that post and will become president of Cities Service Oil.

Award winners for 1959 annual reports are: Continental Oil, first, Texaco, and Standard Indiana (assets over $100 million); Texas Pacific Coal and Oil, first, Plymouth, and Union Oil and Gas of Louisiana (assets under $100 million). Financial World gives these awards each year. Texaco also won an "Oscar" for post meeting report.

Second Arab Petroleum Congress didn't reveal any significant news. The 500 present included delegates from USSR, Yugoslavia, and Romania. Middle East countries still want to hold prices and to increase their take. They are unhappy with the Soviet's cheap oil policy. The Russian delegates condemned oil capitalists companies for high prices and high profits. Since Soviets work on a no-profit scheme, their standards for "reasonable profits" are questionable.

Encouraging is the report that Russia is manufacturing a new large automobile. If the factory will go into high production in economic battle with U. S. car makers, we can all worry less about Soviet oil exports. Another hopeful sign is devaluation of ruble in comparison to dollar although Russian trade is all barter. No rubles leave the country.

Standard-Vacuum will be divided between Jersey Standard and Socony Mobil, each of which owns 50%. Action followed a consent decree in a civil anti-trust case in which Jersey agreed to this division. Socony formed a new operating division to handle its interests; Jersey expects to make a major reorganization for its world operations.

A settlement with Gulf Oil in the same case requires the company to set aside 100,000 b/d oil from Kuwait production for 10 years, placing it at disposal of independent oil companies. Anti-trust suits remain pending against Socony, Texaco, and Standard of California.

Capital expenditures for 1959 by U. S. petroleum industry were estimated at $5,425 million by Chase Manhattan Bank, according to reports released October, 1960. This compares with $5,530 million estimate made by Petroleum Engineer on January 1, 1960.

Oil industry in recovery cycle as a result of (1) rigid mandatory quotas on imports of foreign oil and (2) relative stability of domestic crude oil prices, achieved by drastic production controls in Texas and other Southwestern states. This is conclusion of Goodbody & Company, brokers, in its November Monthly Letter. (See Page E-8 for third quarter reports.)

Offer by Conoco to purchase properties of Calvert Petroleum Company, Tulsa, Oklahoma was announced by President L. F. McCollum, Conoco, and President F. Allen Calvert. Purchase offer was $10,500,000–$4,500,000 in cash and $6,000,000 in reserved oil payments. Under the agreement, Continental will acquire Calvert's 190 oil and gas wells, producing some 1210 b/d oil.

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3 heads are better than 1 . . .

Often a utility electric power company engineer enters into a decision with one or more oil company engineers . . . effecting the economy of operation. This assistance is available anytime to oil producers, pipeline personnel or refinery engineers. As a matter of interest the triple pumper in the photograph pumps simultaneously from three producing zones.

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Course of Oil

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Isn't that the way you feel about it? That's the attitude of an overwhelming majority of U. S. citizens.

What if you'd hired a new employee in your office — would you let him find his way around and expect him to fulfill his duties with no help from you? Right now all you've done is hire a whole squad of political officials, many inexperienced in their new jobs. You can let them fumble along on their own or you can help them.

You're paying a lot for these federal and local governments — you're paying more than you are for rent or groceries or clothes. You're paying a third or more — on the average — of all you earn each year for this governmental complex and the people you've chosen to run it. It isn't a small stake you have in its success. You have the power to mold its shape and bring it closer to your ideals of government.

Imagine yourself a newly elected official. He has requests and demands from all sides — some that he never before considered. In time he'll have to decide about oil and gas problems. Our industry is probably entirely new to him and he hasn't time to study its complicated and confusing organization and working patterns. Where will he get his information?

That depends on you.

You know well the ready tongues and agile wits of our disparagers. You know the semantic effectiveness of "tax loophole" for percentage depletion, of "National Fuel Policy" for end-use control. You have the job of educating the 1961 slate of government officials.

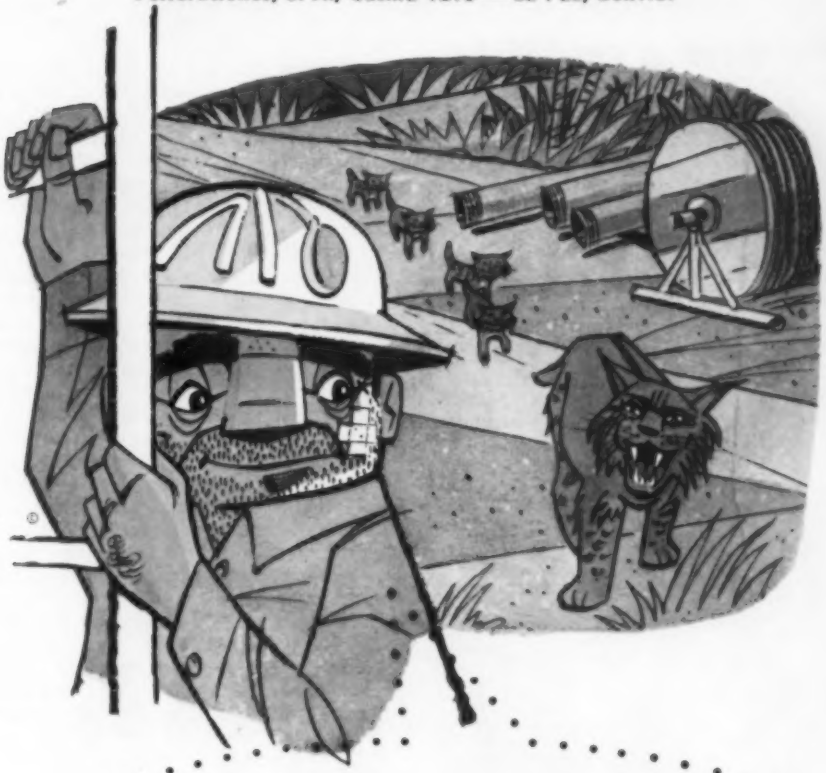
Take those two enemies of 27½% depletion for production — Senator Douglas (D) of Illinois and Senator Williams (R) of Delaware. They are both intelligent men. They have the confidence of their constituents and they listen to them. We've allowed them to harden their stand on depletion when we might have given them a better understanding of how it has increased our resources and protected all consumers. Perhaps it isn't too late even now but it would have been easier if right after these men were first elected we'd begun to show them around the industry and explain how our business operates.

Have you congratulated the new office-holders and told them you'd cooperate in the effort to improve government and make it more efficient? You should do that now. Then watch for hints on appointments to federal and state regulatory agencies and express your ideas immediately. You may escape intolerable conditions by being on the alert and anticipating what could be unfortunate moves by inexperienced politicians.

Your job as a citizen and as a member of the petroleum industry has just begun. You can't be a part-time citizen and expect your country to be run for you without your help. Barnard Baruch became adviser to presidents not by their appointment but by his own diligence in studying government needs. If one-tenth of the people in the petroleum industry would, in friendly concern, provide our new public servants with information directly and briefly, we'd have better government, a better industry, and — what is probably more important — we'd be better citizens.

— Ernestine Adams

Congrats and $25 for this quip to FABIO SORIA GALVARRO, Compañia de Perforaciones, S. A., Casilla 1215 — La Paz, Bolivia.



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petroleum profile

IN THE SUMMER of 1928 a young man who was born and raised in Sioux City, Iowa, made an interesting and important change. He not only moved from the great Mid-West agricultural area to the Pennsylvania oil region, but also entered a new field of endeavor—namely, the promotion and sale of Pennsylvania petroleum products.

This change has resulted in a successful, interesting, and oft-times exciting experience for Forrest O. Koontz, president and chief executive officer of the Quaker State Oil Refining Corporation of Oil City, Pennsylvania.

Up until the time Forrest Koontz started his 32 years' association with Quaker State, his interests and experiences were strictly mid-western. Following military service during World War I, his early business training and experience were primarily with a successful insurance firm in Sioux City, Iowa.

FORREST O. KOONTZ

President, Quaker State Oil Refining Corporation

In his first position with Quaker State, he served as assistant general sales manager of the Quaker State Oil Refining Company which was one of eighteen associated oil firms making up the present corporation. In those early years he took part in developing the sale of Quaker State products on a nationwide basis. He traveled extensively and helped to develop not only a large and well trained field sales organization but also a nationwide group of wholesale distributors, many of whom have also been associated with Quaker State for more than 30 years.

It was during his early years with Quaker State when the Quaker State Oil Refining Company and seventeen associated companies were united into the Quaker Oil Refining Corporation.

In the fall of 1951, Mr. Koontz was named general sales manager, and in December of that year he was elected a director of the Quaker State Oil Refining Corporation. Re-elected a director in 1952 he was also made vice president. In May 1956 he moved to the post of executive vice president, and in May 1957 he was named president and chief executive officer.

Although the first 28 of his more than 32 years with Quaker State were devoted primarily to sales, Mr. Koontz now devotes his time to the over-all direction of Quaker State's extensive business activities including oil producing and refining operations, but still keeps in close touch with the corporation's varied marketing operations. Today the corporation's best known petroleum products, Quaker State Motor Oils and Automotive Lubricants, are sold in all 50 states and in 19 foreign countries.

He has watched with pride extensive developments in research, numerous innovations in over-all management, and improvements which have been made in employee relationships, including a retirement and insurance program and a thrift savings plan for Quaker State employees. The company owns and operates extensive oil-producing properties, pipe lines, three modern refineries, and its own grease plant. Modern packaging facilities have also been established in the Mid-West, on the West Coast, and in Canada.

In addition to his job as chief executive of Quaker State, he has given generously of his time to various oil trade activities. He served as a member of the Lubrication Committee of the American Petroleum Institute from November 1951 to November 1956 when he was appointed to the General Committee, Division of Manufacturing, on which he served until he was made a member of the board of directors of API in November 1959. He is presently serving as a trustee of the National Petroleum Association and is a member of the Marketing Committee of the National Association of Manufacturers. He is also a member of the executive and general committees of the Associated Petroleum Industries of Pennsylvania.

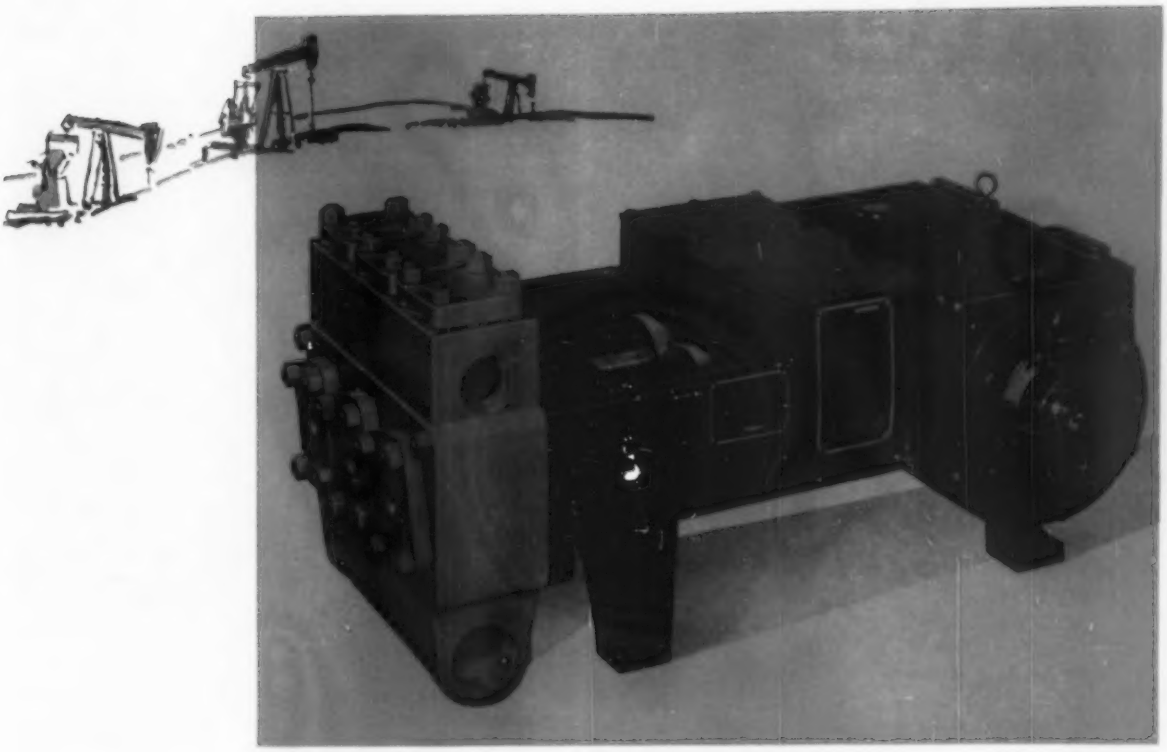
As a member of the board of directors of Oil Centennial, Inc., he played an important part in the extensive celebration in connection with the Centennial of Oil and the 100th Anniversary of the Drake Oil Well, which was held in Titusville, Pennsylvania, in August 1959.

Since September 1948 he has served as a director of the General Telephone Corporation of Pennsylvania. He is also director of the National Transit Company which operates extensive oil pipe line facilities. He is president and director of the Quaker State Oil Refining Company of Canada, Ltd., and director of the Quaker State Oil Refining Company of California, and other operating subsidiaries of Quaker State.

Always interested in various outdoor sports, Mr. Koontz has in recent years made a special effort to devote a few hours regularly each week to his favorite game of golf. Occasional winter vacations spent in warmer climates are usually devoted mostly to golfing. He is an avid baseball fan and endeavors, whenever possible, to see the Pittsburgh Pirates and other major league teams in action.

Mr. and Mrs. Koontz have two children. Their older daughter, Betsy, married to Jack Files, lives in Louisiana. Their younger daughter, Kathryn, is a student at the University of Colorado.

In any discussion about the future, Mr. Koontz likes to point out that no other field of endeavor is more interesting, presents better opportunities, or offers a greater challenge than the oil business.



"Oilwell's" 3-inch stroke plunger pump is just right for small waterfloods!

The A-323 Triplex Plunger Pump is of sturdy, horizontal, three-cylinder, single-acting construction. It is specifically developed for small waterflood and salt water injection programs.

Compact aluminum-bronze fluid end is designed with double suction and discharge connections. Removable stuffing boxes accommodate plunger sizes from 1¼ to 2½ inches for working pressures from 3,000 to 815 psi. It is equipped with stainless steel plate-type valve service with nylon or stainless steel discs.

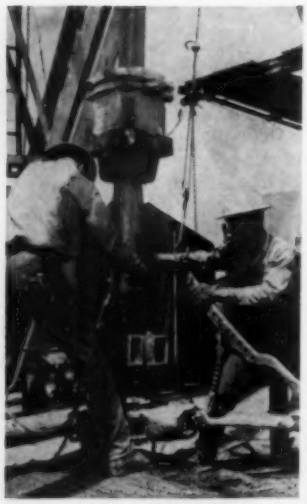
The power end is a high-strength cast-iron frame with integral cross-head guides. Crankshaft is mounted in shim-adjustable tapered roller bearings.

You can get more information about this 3" stroke, 50 hp plunger pump, including specifications and performance data, at your nearest "Oilwell" store or from your "Oilwell" representative.

USS and "Oilwell" are registered trademarks

USS Oil Well Supply Division of United States Steel

Executive Offices—Dallas, Texas
Export Offices—30 Rockefeller Plaza, New York 20, N. Y.



the conference table

$1 Billion for Basic Research

Funds for basic research in the United States reached a level of $1 billion in the year 1959-60, estimates National Science Foundation. The substantial rise in the level of basic research funds is part of a "long-term increase in scientific and technological activity stimulated, in particular, by the challenging problems of the past two decades," the Foundation said.

Colleges and universities expended about half the national total. The industry sector used about a third of total funds. Performance of basic research by both the Federal Government and other non-profit institutions accounted for only 13%, and 6%, respectively.

"The world must learn to work together, or finally it will not work at all." — Dwight D. Eisenhower.

Take a Look at Tomorrow

Peter F. Drucker always seems to see a little farther into the future than most of his contemporaries. He wrote his "Landmarks of Tomorrow" in 1957 and it was reprinted in 1958 and 1959. It's certainly worth reading in 1960.

In one place Drucker discusses planning and points out that we have a choice between local plan and no plan. Centralized planning, he says, is impossible. The risk of failure converts it into chaos and tyranny and makes its certain outcome collapse. We have to plan, he said, but to expect any one plan to come out right is folly and so is expectation that any one group of planners will come out right no matter how many alternative plans they develop. Elementary mathematics shows that the outcome of such a gamble must be worse than to have no plan at all and to leave all to chance.

"At the same time the very stake in his planning forces a centralized planner to try to control everything; anything uncontrolled becomes a danger. Centralized planners would probably tend to become tyrants anyhow; absolute power always hungers for more power. But even if the planners did not want to tyrannize, centralized planning for the entire economy or for the entire society propels them inevitably toward it. The more the central plan embraces, the riskier the venture, the greater the odds against its success."

This is a brief glimpse into the promises and the dangers that Drucker describes in the new frontiers of the Free World. Most executives read everything Drucker writes and this one should certainly not be missed. It is published by Harper & Brothers, 49 East 33rd Street, New York 16, New York. Price $4.50.

"One example is more valuable than 20 precepts written in books." — Roger Ascham.

International Gains Striking

A ten-year forecast of free world production and population is reported in a booklet with 33 charts and all information printed in five languages. The international study was prepared by McCann-Erickson, Inc., advertising agency.

The company said "For the first time in two decades, world production capacity is equal to current demands." This brings intensified competition at the same time as unprecedented expansion. The 30-page report entitled "The Decade of Incentive" may be obtained by writing to Corporate Information Office, McCann-Erickson, Inc., 485 Lexington Avenue, New York 17, N. Y.

"It has been amply proved that business can carry corporate fat only at the risk of a corporate coronary." — John E. Swearingen, President, Standard Oil Company (Indiana).

Things to Remember

The great Marshall Field has long since gone to his reward, but he left behind him many worthwhile things besides the world-famous department store which bears his name. Not least among these bequests to mankind is the following bit of advice entitled, "Twelve Things to Remember." They are:

1. The value of time
2. The success of perseverance
3. The pleasure of working
4. The dignity of simplicity
5. The worth of character
6. The power of kindness
7. The influence of example
8. The obligation of duty
9. The wisdom of economy
10. The virtue of patience
11. The improvement of talent
12. The joy of originating

"America is a 'happy-ending' nation." — Dore Schary.

Up in the Air

Privately owned business aircraft in service in the United States at the beginning of 1960 numbered 28,318, according to the National Business Aircraft Association. These included 5790 multi-engined fixed-wing machines and 78 helicopters; the total a year before was 26,148. Business aircraft operations in 1959 covered 855 million aircraft miles, involving an overall consumption of aviation gasoline and turbine fuel of 138 million gallons.

Exclusive LUFKIN Chrome Clad® lines defy grit, grease, gravel—and rugged use!

Here are "he-man tapes" that work like troopers when the job's toughest!

Easy-to-read markings will *stay* easy to read, because they're bonded to steel, electroplated and chrome coated. Lines won't kink or break. Sturdy metal construction (except for carrying handle). It all adds up to two-fisted quality that *lasts!*

Exclusive quality features are yours in *all* Lufkin tapes. For example:

Lufkin Chrome Clad® DERRICK Tape (above, left) gives you instant readings on a line that won't rust, chip or peel. An extra-sturdy line, ¼" wide, with hook and ring. Lock-handle frame. Turn handle over, lock line at any point. Available in 100-200' lengths.

Lufkin "ATLAS" Gaging Tape (above, right) gives you easier reading, too, with durable, jet-black markings on glare-free line. Line is 50% heavier than standard. Has 20-ounce plumb bob, and sturdy lock-handle frame.

See your Oil Supply House.

Measure for measure, the finest made...

LUFKIN

SAGINAW, MICHIGAN

"When a man is really important, the worst adviser he can have is a flatterer." —Gerald W. Johnson

Research Aid for Argentina

Armour Research Foundation will aid Argentina's newly-formed National Institute of Industrial Technology in formulating a program of assistance to Argentine industry, according to Paul B. W. Gollong, director of ARF's international research.

During a three-month program, Dr. Milton E. Nelson, international research advisor, will assess the research needs of Argentine industries, the availability of research facilities, and personnel and development of a program for continued aid to industry. The National Institute of Industrial Technology is a semi-government supported research organization. Argentine industry, under this arrangement, will have access to the research facilities at a nominal charge. Part of Nelson's role will be to make industry aware of the value of research.

"Next to knowing when to seize an opportunity, the most important thing in life is to know when to forego an advantage." —Benjamin Disraeli

Looking Through the "National Fuels Policy" Idea

A big slice of oil and gas markets could be taken away, says Eugene Hosford, Texas chairman of the Oil Information Committee of the Texas-Mid-Continent Oil & Gas Association . . . IF a strongly-backed move in Congress is successful. Coal producers and their business allies are seeking establishment of a "National Fuels Policy" under the harmless-sounding request to have a fuels "study" made.

Industry leaders believe that the ultimate purpose of the pending legislation is to establish "end-use" control of fuels, says Hosford. Such would prescribe by legislation what kind of fuel consumers could use when and where. If adopted, it could cut deeply into the already squeezed markets of our industry and everybody in it would feel the adverse effects.

"Many ideas grow better when transplanted into another mind than in the one where they sprang up." —Oliver Wendell Holmes

Archaeologic Find Made by Mobil

In the reception room at Mobil's London office hangs a bronze sword dredged up from the Thames River recently when the company was working on the jetty at its Wandsworth Works. It is in almost perfect condition and is said to date back from 1000 to 450 B.C. It is not only the pipeline industry that uncovers artifacts.

"One example is more valuable than 20 precepts written in books." —Roger Ascham

On Union and Management Negotiations

In a recent "Relations News Letter" published by General Electric for circulation among its management, was a brief analysis of the depth study made by G.E. under the heading, "The Complex Problems of Employment Insecurity." The introduction is a thought-provoking statement quoted below:

"Union and management negotiators at many bargaining tables periodically seek alleviations of one of the most difficult problems of a free society. It is a problem which scholars and many other well-informed and well-intentioned people have historically failed to solve.

"It is a problem which has been with us since the industrial revolution brought us, on the one hand, economic freedom and relative material abundance, but on the other, problems of this type.

"It is the problem of how to eliminate unemployment and insecurity in an economy which preserves individual freedom to choose between competing offerings . . . in an economy in which the free customer by his often-unpredictable actions can make or break companies, and create or destroy jobs.

"It is the inevitable problem of employment insecurity."

"There's nothing that cuts into a conversation like a revolving door." —Don Herold

Reason for So Many Inquiries From Abroad

In this issue you'll find a Reader Inquiry Card to get you more information on the New Equipment and Literature items and advertised products.

Not long ago, we received one of these cards with most of the items circled asking for more information. We wrote the sender, and thought you'd enjoy his reasons as outlined in his letter:

"I am Drilling Superintendent of OMVAG (Ref: *The Petroleum Engineer*, Sept. 1959, pg. E-8) and at the present time we have 12 rigs drilling, one of them now drilling below 13,000 ft, Austria's deepest.

"Last year we bought two complete Ideco Super 7-11's, two Cardwell J-450's, five Ideco Full View Masts to modernize older rigs, and a lot of other equipment from many different U. S. manufacturers: Cameron, Shaffer, Hydril, Bowen-Itco, Baker Oil Tools, Martin-Decker, Varco, Mission, Byron-Jackson, National Supply, Baylor, Magcobar, Servco, Driltrol, Hughes, Reed, etc., etc.

"All the equipment which we buy from the U. S. is ordered through my office, and this is the reason why I am interested in many things shown in *The Petroleum Engineer*, and why I circle more numbers on your Reader Service Card. There is a definite difference between the U. S. and Europe. Over here, if you don't ask for information, you won't get it. In the U. S., you'll find it without asking for it . . . every morning, many pamphlets, bulletins and catalogs from manufacturers on your desk. They keep you informed in the states even if you don't use a Reader Service Card from one of the many trade journals.

"I hope that you can now understand why someone in Europe may circle more items on your Service Card than anyone in the U. S. And, I hope that you won't be too angry that we over here cause you more work than our colleagues in the states.

"In 1959-60, I had the chance to spend six months in the United States to study your equipment and your methods. I was very impressed and I am sorry that I didn't visit you in Dallas."

Sincerely,
Dipl. Ing. Hermann Sporker

It is one of our primary functions to be of service to the international petroleum industry . . . and, you can be sure, Mr. Sporker, that we were happy that we could provide the medium through which it was possible for you to keep abreast with new developments. And, we're almost certain that those companies involved were also happy you made the inquiry . . . and, that you read *The Petroleum Engineer*.

Good Wells Make Good News

A Report on Recent Profit-Increasing "Workover" Treatments

December, 1960

"Workover" treatments by Dowell have made many old wells more profitable to their operators. Here are four recent examples showing how Dowell products and services improved wells for operators:

- **Lea County, New Mexico** (Old Oil Well) This well, completed in the Drinkard formation of the Blineberry pool, had lost production completely due to gyp deposits. First, 200 gallons regular acid with surfactant added were spotted on bottom for 24 hours and then pumped out. Next, a 600-gallon solution containing 180 gallons of Versene® 100, water, and a surfactant was spotted on bottom. This solution was allowed to soak for 48 hours, then circulated for 24 hours. After treatment, well flowed 140 bopd.

- **Saskatchewan, Canada** (Old Oil Well) This well, completed into the Mississippian in 1957, was given several acid treatments with no results. Well was temporarily abandoned. Dowell recently suggested Abrasijet* — Dowell's abrasive jetting service — to slot casing and formation. Four slots were cut — two at 4584 and 4585 feet, and two between 4571 and 4575 feet. 12,000 pounds of 20-40 mesh sand were used. Differential pressure across jets was from 3000 to 3500 psi. Well started making 25 bopd. Treatment cost of $1185.00 is expected to pay out quickly. In addition, a valuable well was saved.

- **Gray County, Texas Panhandle** (Old Oil Well) This Panhandle dolomite well had been shot with nitro from 2885 to 3285 feet on initial completion. Subsequent treatments included several acidizing and fracturing jobs. Production had dropped to 7 bopd. Dowell fractured using 16,000 gallons gelled water, 80,000 pounds sand and 5000 pounds salt. Treatment was divided into two equal stages. Salt was injected with 1500 gallons frac oil between stages to act as a temporary plugging material. Injection rate of fracturing fluid was 45 bpm. Pressure was zero during first stage and 300 psi during second. 45 days after treatment, daily production was 42 bopd.

- **Crook County, Wyoming** (Old Oil Well) Production from this well had declined from 200 bopd after fracturing on initial completion early in 1959 to 80-90 bopd just before treatment on August 1, 1960. Pay was the Dakota sand of the Miller Creek pool from 5924 to 5944 feet. Dowell used the "Frac Guide"* to help plan a treatment for this well. A 250-gallon Mud Acid spearhead was followed by Petrojel*. 20,000 gallons gelled lease crude with fluid loss additive carried 20,000 pounds sand. Injection rate was 24 bpm at 1800-2300 psi. Production 30 days after treatment was 480 bopd flowing. Cost of the frac job was paid out in less than 10 days.

Investigate the many services and products offered by Dowell to help you boost profits by making your wells worth more. For detailed information — or for prompt service — dial Dowell. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina, France, Germany and the Sahara area. Dowell, Tulsa 1, Oklahoma.

*DOWELL TRADEMARK

Services for the oil industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

NEW

CLAYTON MARK

Parkerized

FITTINGS

- **RUST PROOF, CORROSION-RESISTANT**
- **CARBON AND ALLOY**
- **SCREWED AND SOCKET WELD**
- **2000, 3000, 4000, 6000 p.s.i.**

Now you can buy a complete line of *Parkerized* Fittings from the same source that has supplied you with high pressure Unions and Valves since 1912. In sizes ⅛" to 4", these forged steel, clean-looking fittings resist corrosion "forever" on shelf or in high-pressure steam, water, oil, gas and air applications. Eliminate duplicate paperwork . . . order all your piping requirements from your Clayton Mark Distributor. Have the best yet save time and money —specify Clayton Mark!

AVAILABLE IN 50 STATES AND THROUGHOUT THE WORLD

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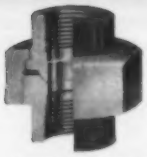
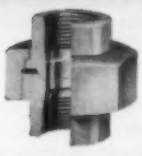
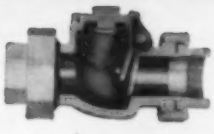
HOT FORGED STEEL HIGH-PRESSURE UNIONS AND VALVES



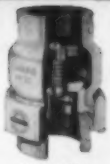
"PETRO" CARBON STEEL UNION



PETRO" STAINLESS STEEL UNION



SWING CHECK VALVE



"PETRO" CHECK VALVE

"BEVELED" ORIFICE UNION

From RCA The Most Trusted Name In Electronics

RCA 110 Electronic

Engineered to withstand the rigors of industrial environment...an ultra high-speed control system ...tailored to your exact needs

The RCA 110, an advanced solid state industrial computer, offers capabilities that range from simple automatic monitoring and recording to complete real-time computer control of complex industrial operations.

From its very concept, the RCA 110 was designed for continuously operating processes, and built for maximum effectiveness under the hardest industrial usage. It is housed in dust-tight heavy steel cabinets and air-cooled by internal heat exchangers to guard against contamination from outside atmosphere. The entire system is programmed so that it will continuously check itself. In the event of main power failure, the RCA 110 calls into action a "safe shutdown" sequence without loss of computer memory or instability to the controlled system. Wired-in priority interrupt helps make the RCA 110 the most efficient industrial computer offered anywhere.

Like all RCA Electronic Data Processing Systems, the "building-block" concept of the RCA 110 permits custom-assembly of the system according to your special requirements, and easy expansion as your needs demand.

For detailed information on the world's most advanced industrial control computer, ask your nearest representative of the Foxboro Company, or write —Industrial Computer Systems Dept., Electronic Data Processing Division, RADIO CORPORATION OF AMERICA, 21 Strathmore Road, Natick, Mass.

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

6 REASONS WHY THE RCA 110 IS THE WORLD'S MOST EFFICIENT

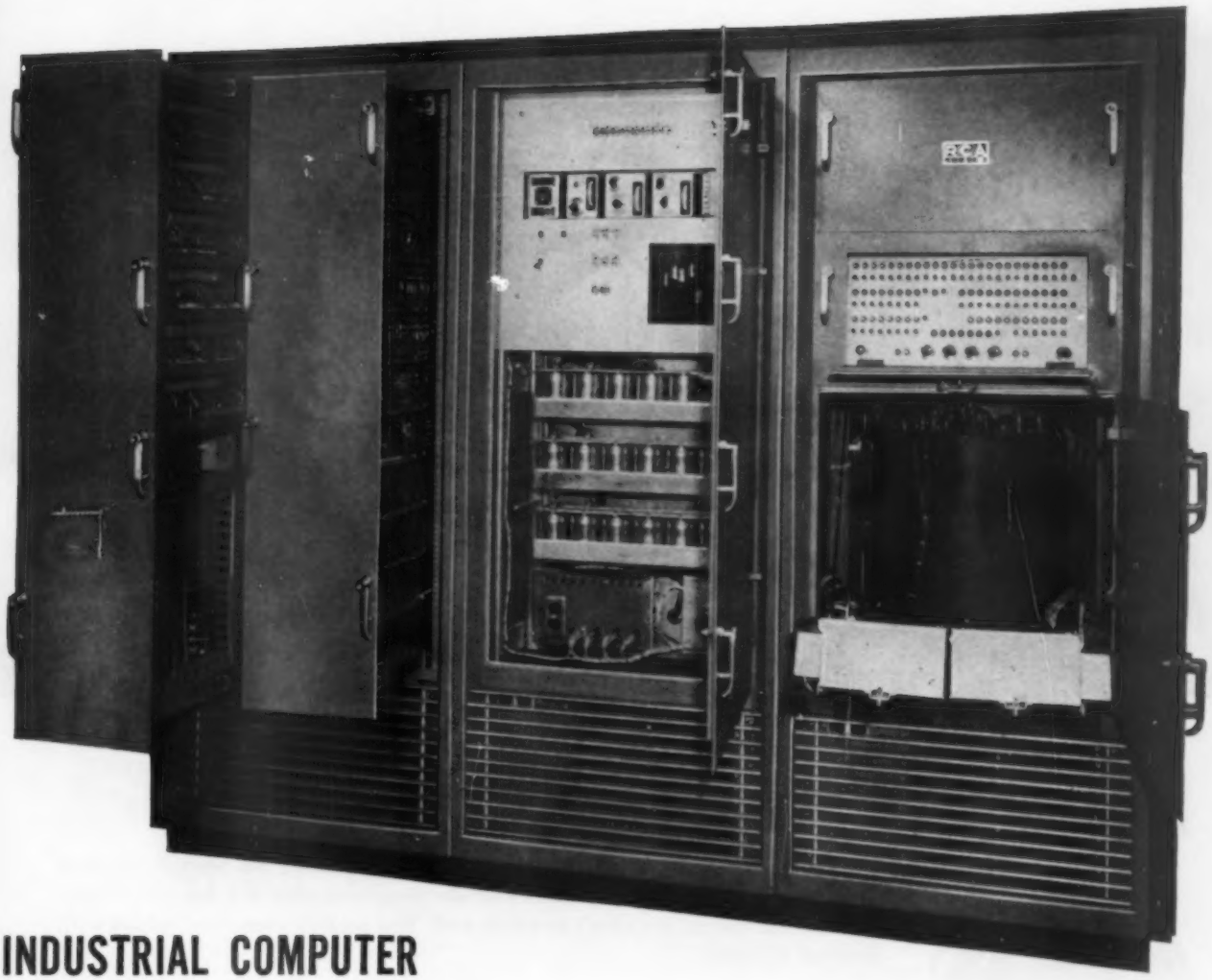
DESIGNED FOR FAIL-SAFE CONTINUOUS OPERATION even under the most exacting factory conditions. Dust-tight, heavy-duty all-steel enclosures are equipped with industrial heat exchangers for internal cooling to prevent contamination from outside atmosphere. Requires no false flooring or other special site preparations.

UNIQUE PRIORITY INTERRUPT FEATURE enables computer to automatically select the most urgent task from multiple demands. Operates on programmed priority basis, to avoid traffic jams and to handle emergency situations immediately. Result—programs are easier to write, memory space is conserved, and computer free time is automatically assigned to self-checking routines.

MAXIMUM SYSTEM ACCURACY IS SAFEGUARDED with low impedance, single path ground scheme—permits low level signals to be processed by computer, eliminating cross talk interference from main frame currents. Employs solid copper, 150 pound bus bar as integral part of grounding system.

HEAVY DUTY SOLID STATE POWER SUPPLY includes separate metering and adjustment of all DC voltages, automatic alarming of over-voltage, and circuit breaker protection against current overload. Motor driven control eliminates start-up shock and prolongs life of all components. Reserve capacities in power supply, plus priority interrupt routine, safeguard memory information, and safely shut down the computer in event of main power failure. Entire system sectioned and metered for high-speed, automatic check-out.

Industrial Computer System



INDUSTRIAL COMPUTER

EASY MAINTENANCE EVEN DURING OPERATION—all circuits accessible from front in extendable drawers and hinged chassis. Industry's most complete maintenance panel permits manual check-out of complete system. Computer continues to operate with all drawers fully extended. Circuits are designed to perform at high temperatures—have built-in marginal testing, and an automatic alarm signals improper operating voltages.

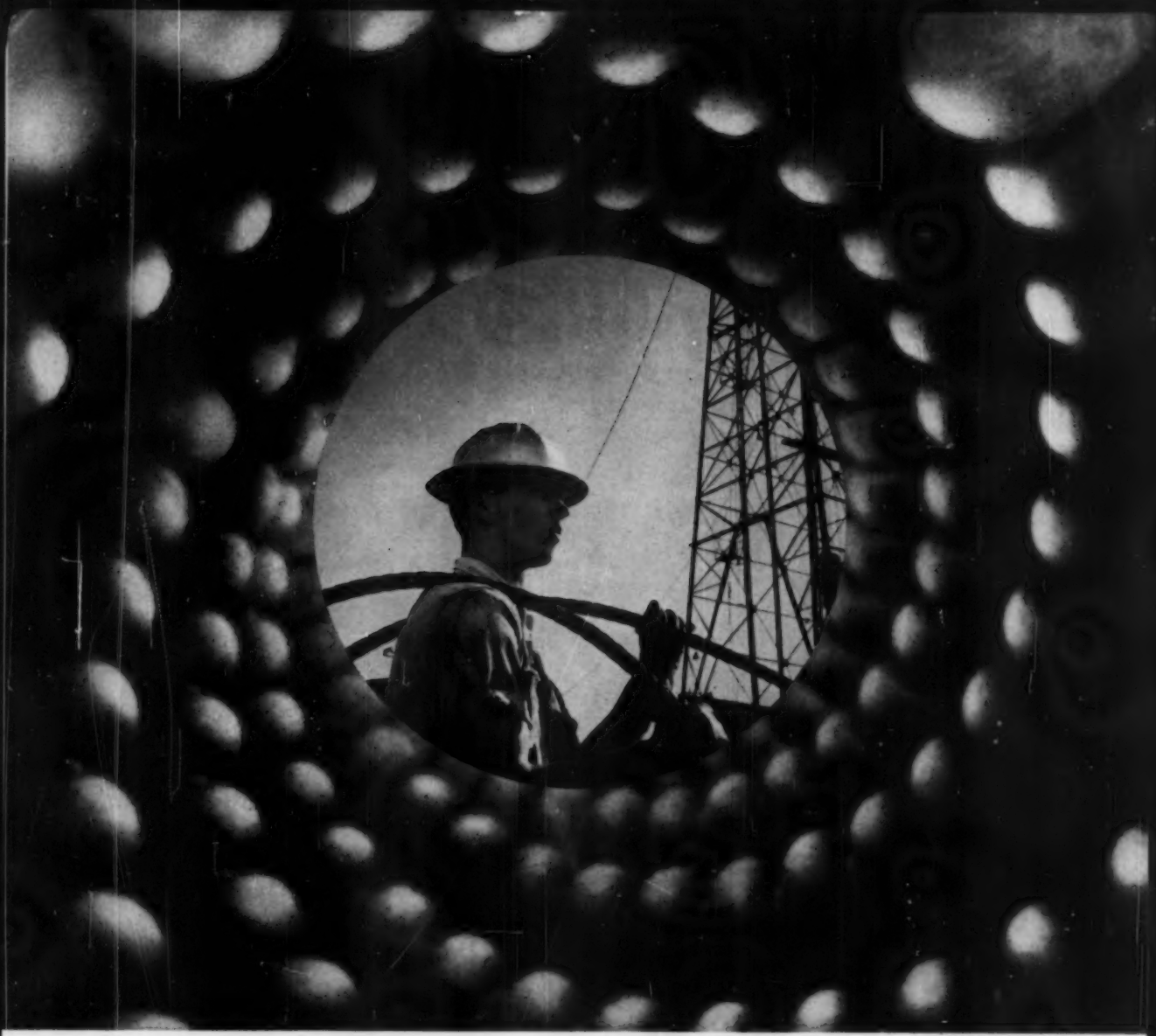
MODULAR DESIGN PERMITS FIELD EXPANDABILITY — both drum and core memories can be expanded in the field within a few hours as additional tasks are assigned to the computer or the number of inputs, outputs, and data manipulations are increased.

COMPARE THESE PERFORMANCE SPECS

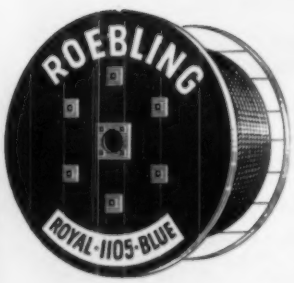
Speed — including access time and staticizing, adds in 56 microseconds, multiplies in 728, divides in 868. *Instructions*—one address (limited two address), 7 indexable address registers, 71 wired-in instructions. *Number System*—fixed point, binary or binary coded decimal. 24 bit word length, word time 28.89 microseconds. *Working Storage*—magnetic core, coincident current, variable in size from 256 to 4096 words, 8 high-speed input-output registers, clock frequency 936 kilocycles. *Bulk Storage* — magnetic drum, 3600 rpm, 4096 to 51,200 words, 8.3 milliseconds average access time, 200 kilocycle transfer rate, up to 12 buffer tracks for input-output. *Size*—82" high, 34" deep, 105" long. *Typical Power Input*—5 kva. 220 volts.

signed to self-checking routines.

sectioned and metered for high-speed, automatic check-out.



ROEBLING ROYAL BLUE WIRE ROPE DESIGNED AND MADE TO SERVE YOU WELL



ROYAL BLUE: *We put a lot of work into it—You get a lot of work out of it.*

This is the inside view of Roebling Royal Blue — its core has been removed to show the uniformity and symmetry of the rope structure. It's not only what's outside that counts; it's what's *inside* as well. You see how concerned we are with internal security.

All the inspections and tests that Royal Blue goes through enable us to know that the rope we build will do what we sell it to do. These quality control measures help us — as they do you — to take the *long* view of Royal Blue. A brochure on long-lasting Royal Blue, its resistance to shock, abrasion, crushing and bending, is available on request. Ask your Roebling wire rope distributor or write to Roebling's Wire Rope Division, Trenton 2, New Jersey.

ROEBLING

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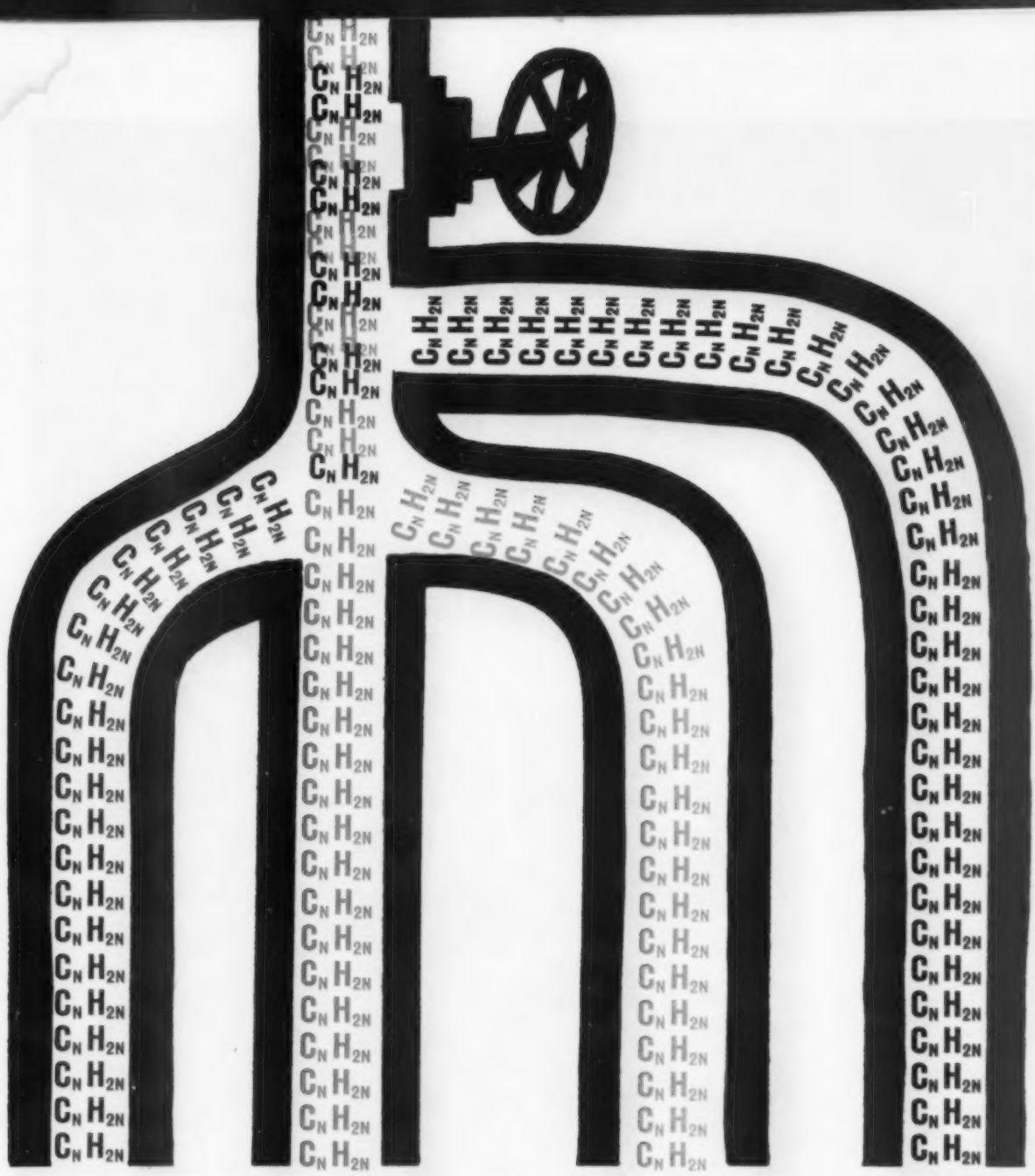
are increased.



Need olefins? Any olefins? Talk to Gulf!

Gulf is already a major ethylene supplier—over two billion pounds in seven short years. This is the keystone of Gulf's basic olefin experience.

Currently we're also supplying merchant propylene, heptenes, nonenes and dodecenes. And if you require other olefins, we can make them for you. We have top technical service people . . . and facilities for making highest purity material (our ethylene is running 99.8% minimum). And you can be sure of dependable supply.

Let's discuss your requirements. Write or call Petrochemicals Department Sales Office, Gulf Oil Corporation, 360 Lexington Avenue, New York 17, New York.

Quality Petrochemicals to Begin With

Benzene • Cyclohexane • Ethylene • Isooctyl Alcohol • Propylene • Propylene Trimer and Tetramer • Sulfur • Toluene

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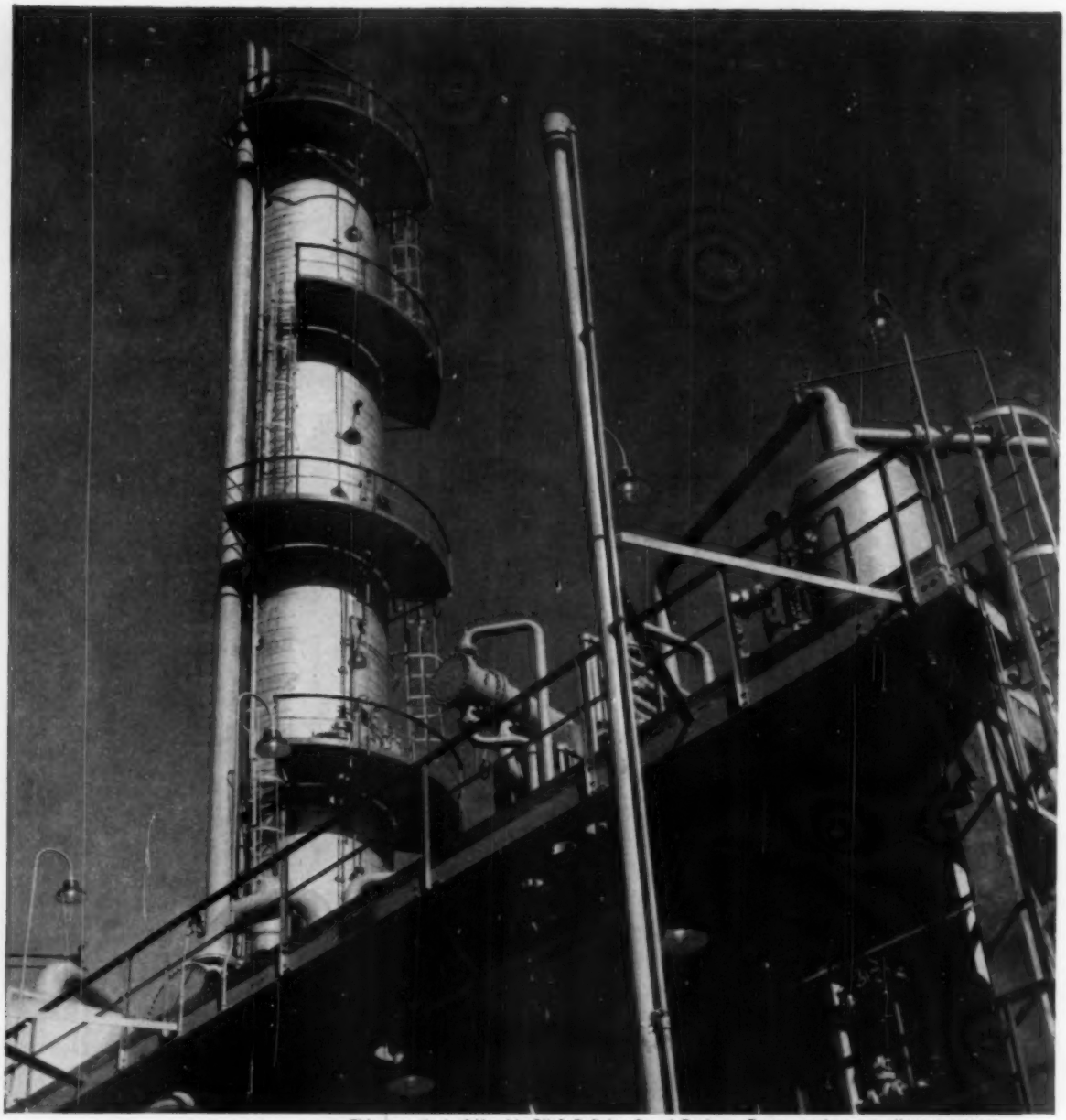

This new plant of Humble Oil & Refining Co. at Baytown, Texas, employs a continuous process for producing large quantities of polypropylene- raw material for a wide variety of useful plastics.

"We cannot afford to be inefficient in the use of capital or labor. We must aim at increased national productivity; we must stimulate research and invention; we must reward ability and initiative; we must encourage capital generation and productive investment. If we fail to do these things we will move backward in the world picture instead of forward."

–Leo D. Welch, Chairman of the Board

Standard Oil Company (New Jersey)

NEW TETRAMIX*

ANTIKNOCK COMPOUND SAVES ROAD OCTANE DOLLARS

HOW

REFINERY "A"—a large one—recently discovered it could blend its stocks to provide the desired road octanes in their regular and premium gasolines ***at a 15% saving in antiknock costs,*** using Du Pont TETRAMIX in place of TEL.

REFINERY "B"—producing only straight-run gasoline and catalytic reformate—was paying a premium price for high octane blending stocks to make gasolines with acceptable road octane numbers. They discovered that by using TETRAMIX instead of TEL they could save 6% on their antiknock costs and eliminate the need for purchasing the blending stock. At the same time, the customer was given a gasoline with a higher road octane number but with the same research octane.

BEST OF BOTH TEL, TML New antiknock economy is often possible with Du Pont TETRAMIX as in the above actual cases, because it combines the best of both tetraethyl lead and tetramethyl lead. TETRAMIX is a combination of all possible methyl-ethyl lead compounds, including small amounts of TEL and TML. ■ This gives you a single additive with the combined benefits of TEL and TML which could not be obtained by physically mixing the two compounds. ■ In many fuels, TETRAMIX is more effective than TEL or TML in attaining desired octane values, on a cost-per-gallon basis. ■ It costs less per pound than TML and is effective in low, medium or high concentrations. ■ **IMPARTIAL ANTIKNOCK SERVICE** Because Du Pont offers all three compounds—TEL, TML and TETRAMIX—you can get impartial help in selecting the one additive best suited to your particular gasoline stocks. Our linear programming service can also help you evaluate the relative economics of each blend. ■ For more details on Du Pont TETRAMIX, get in touch with your Du Pont Petroleum Chemicals Representative. Or contact: E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

*Trademark

DU PONT

DU PONT LEAD ANTIKNOCK COMPOUNDS AND OTHER PETROLEUM ADDITIVES

Better Things for Better Living . . . *through Chemistry*

API Report

U. S. DEMAND FOR CRUDE OIL

Annual growth in oil consumption has been reduced in last five years, says author, and he explains why

MINOR S. JAMESON, JR.

THERE HAS BEEN INCREASING EVIDENCE of a significant and perhaps fundamental change in the demand for crude oil in the United States during the past year. This paper presents:

1. *A summary analysis of the factors involved in crude oil demand*
2. *Projection of the probable outlook for the next 3 to 5 years*
3. *Commentary on this changing situation in relation to the industry's operation and policies.*

It is important to differentiate between total consumer demand for petroleum products[1] and total refinery demand for crude oil.[2]

Total consumer demand for products represents total requirements for gasoline, jet fuel, kerosine, diesel fuel oil, home-heating oils, industrial fuel oil, and all other finished petroleum products including liquefied petroleum gases. Crude petroleum is, of course, the basic raw material from which these finished products are derived. It would seem, on the surface, that there should be little or no difference between the demand for products and the demand for crude oil. Increasing consumer demands for finished products, it would seem, should require corresponding increases in refinery requirements for crude oil. As will be seen, however, the refinery demand for crude oil differs from the demand for petroleum products.

To illustrate, total demand for petroleum products increased by almost 700,000 b/d from 1956 to 1960. In contrast, total demand for crude oil in 1960 is the same as in 1956. In analyzing the trend of crude-oil demands, it is necessary to consider:

1. What appears to be a fundamental change in the rate of growth of consumer demands
2. Factors that account for the difference between total demand for products and total demand for crude oil.

[1]Total consumer demand for petroleum products, total demand for products, total oil consumption, and similar terms are used to refer to "Total Demand for All Oils" as defined in government and industry statistics. This total demand includes exports of crude oil and refined products and domestic demand for all liquid products.

[2]Total refinery demand for crude oil, total demand for crude, and similar terms are used to refer to total domestic and foreign crude oil used in U. S. refineries, crude-oil exports, crude oil used direct as fuel, and crude-oil losses. Crude used in U. S. refineries accounted for more than 99% of total crude-oil demand in 1959.

Demand for Products

A slackening in the rate of growth in oil consumption since 1955 has been the most important factor affecting the demand for crude oil.

During the 10 years prior to World War II, total demand for petroleum products increased at an average rate of 5.5% per year. The average annual growth in the 10 post-war years ending in 1955 was 5.5%. But, from 1955 to 1960, domestic oil consumption showed an increase of only 2.1% per year. Had consumption continued to increase at an annual rate of 5.5%, total demand for petroleum products in 1960 would be 1,600,000 bbl daily greater than the current level. Clearly, the reduced rate of growth in demand for petroleum products has been the major factor affecting the demand for crude oil.

The slow-down in U. S. oil consumption may be temporary, but the evidence points strongly to the probability of a fundamental change. Increasing use of natural gas as a source of energy is not a new development since 1955 and provides no explanation, for example, for the fact that the rate of growth in gasoline consumption has been cut in half. For a time, there was speculation as to the adverse effect of the 1958 business recession on oil demands, but later developments showed that demands did not increase as expected in the period of recovery from that recession.

The full explanation for the change in the trend of consumer demands for petroleum products is a matter for further study by those engaged in market research.

Various considerations are involved. For example, part of the growth in oil demands has been due to the taking of markets in transportation and heating previously supplied by coal. Potentialities for growth in this area have been largely exhausted. Such considerations, including the trend toward smaller cars, appear to be contributing to a basic change in the rate of growth in the total demand for petroleum products.

Demand for Crude Oil

Recognizing the impact of a lower rate of growth in oil consumption, the question remains as to why there has been no increase in crude-oil demand since 1956 when the total demand for petroleum products increased by almost 700,000 b/d. Table 1 summarizes the factors involved in the difference between consumer demands for finished products and the refinery demand for crude oil.

MINOR S. JAMESON, JR., *executive vice president of Independent Petroleum Association of America, presented this paper under the title "A Review and Forecast of U. S. Demand for Crude Oil" at the Production Session of the American Petroleum Institute, Chicago, Illinois, November 15, 1960.*

Jameson joined the economics division of the Federal Trade Commission after receiving his BS degree from Massachusetts Institute of Technology. In 1937 he went with IPAA as petroleum economist. During World War II, he served in the office of the Quartermaster General and has been a consultant to the office of Civil and Defense Mobilization and the U. S. Department of the Interior. He became assistant to the IPAA president in 1950 and was appointed in 1958 to his present position.

TABLE 1.

	Thousand barrels daily		
	1956	1960	Change
A — Total demand for petroleum products	9209	9900	+691
B — Change in inventories	+179	−110	−289
C — Imports of residual fuel oil, reflecting "upgrading" of crude oil	445	660	+215
D — Imports of other finished products and unfinished oils	57	160	+103
E — Domestic production of natural-gas liquids	801	930	+129
TOTAL C, D, and E	1303	1750	+447
F — Demand for crude oil (domestic production and crude imports)	8085	8085	—

(Source: U. S. Bureau of Mines; year 1960 partly estimated)

As shown in Table 1 the failure of crude-oil demand to increase, despite the increase in oil consumption, can be attributed to 4 factors:

1. Inventory changes
2. "Upgrading" of crude oil by U. S. refineries to produce more lighter products from a barrel of crude, accompanied by increased imports of residual fuel oil
3. Increased imports of other finished products and unfinished oils, including increased shipments from Puerto Rico
4. Increased domestic production of natural-gas liquids.

TABLE 2.

	Thousand barrels daily		
	1956	1960	Change
Crude production	7150	7060	−90
Crude imports	935	1025	+90
Total	8085	8085	—
Crude producing capacity	8929	9708	+779
Crude refining capacity	8381	9543	+1162

(Source: Production and imports from U. S. Bureau of Mines, with 1960 partly estimated. Producing capacity as of January 1 from reports of IPAA Productive Capacity Committee. Refining capacity as of January 1 for operating refineries from U. S. Bureau of Mines.)

Keeping in mind the fact that total demand for crude oil in 1960 is the same as in 1956, the changes (Table 2) in domestic crude-oil production, crude-oil imports, domestic crude-oil producing capacity, and U. S. crude-oil refining capacity are significant.

Outlook for Demand

The preceding analysis provides a basis for projecting the probable trend of U. S. demand for crude oil during the next 3 to 5 years and the conditions as they are known today, it seems reasonable to anticipate a growth in oil consumption no greater, and probably somewhat less, than total U. S. energy requirements which show a long-term increase of less than 3% per year. On this basis, total demand for petroleum products during the next 3 to 5 years may be expected to increase at an average rate of 2.0 to 2.5% per year.

There is little doubt that increasing production of natural-gas liquids will continue to supply a part of the increased demand. Continued "upgrading" of crude oil by increasing the refinery yield to produce more lighter products from a barrel of crude may be expected to supply an additional portion of the increase in consumption.

Taking such factors into consideration, the total demand for crude oil is estimated to increase by only 1.0 to 1.5% per year from 1960 to 1965. This would provide an additional market of only 100,000 to 150,000 b/d per year for increases in domestic crude petroleum and/or increases in imports of crude oil from Canada and other foreign sources.

Concluding Comments

The foregoing analysis of U. S. demand for crude oil, it is suggested, has a greater significance than the satisfaction of an economist's or statistician's curiosity. The rate of growth in demand for petroleum products has slackened. There has been no increase in the total demand for crude oil since 1956. Such fundamental changes in demand have a bearing on industry operations, management policies, and government policies at the state and federal level.

Historically, exploration and development activity, pipeline construction, state conservation programs, import policies, and a host of related considerations have been geared to a substantial and continuing growth in U. S. oil consumption and in U. S. demand for crude oil. There has been a continued and substantial expansion in U. S. producing and refining capacity since 1956 when there was no increase in the total demand for crude oil.

Today, there is persuasive evidence of a more moderate rate of growth in oil consumption and relatively small increases in the total demand for crude oil. Under these changed conditions, each company will be studying more carefully than ever the development of its facilities, its refinery operations and its inventory situation. Each of these factors has greater significance than before. These problems involve every branch and segment of the industry.

The industry is confronted with a seeming dilemma. On the one hand are the problems created by a lower rate of growth; on the other — the task of finding and developing the tremendous reserves that will be required to fuel the nation's future economic progress and security.

Over the long range, the controlling determinant of future oil supply will be the policies of government (state and federal): the continuation of sound tax provisions; the maintenance of a proper balance between imports and domestic production; the freedom of gas production from utility regulation; and sound conservation programs of the producing states.

In contrast, the immediate problems arising out of the reduced rate of growth in oil demands constitute primarily a challenge to industry management and industry leadership. The welfare of the entire industry is at stake. ★ ★ ★

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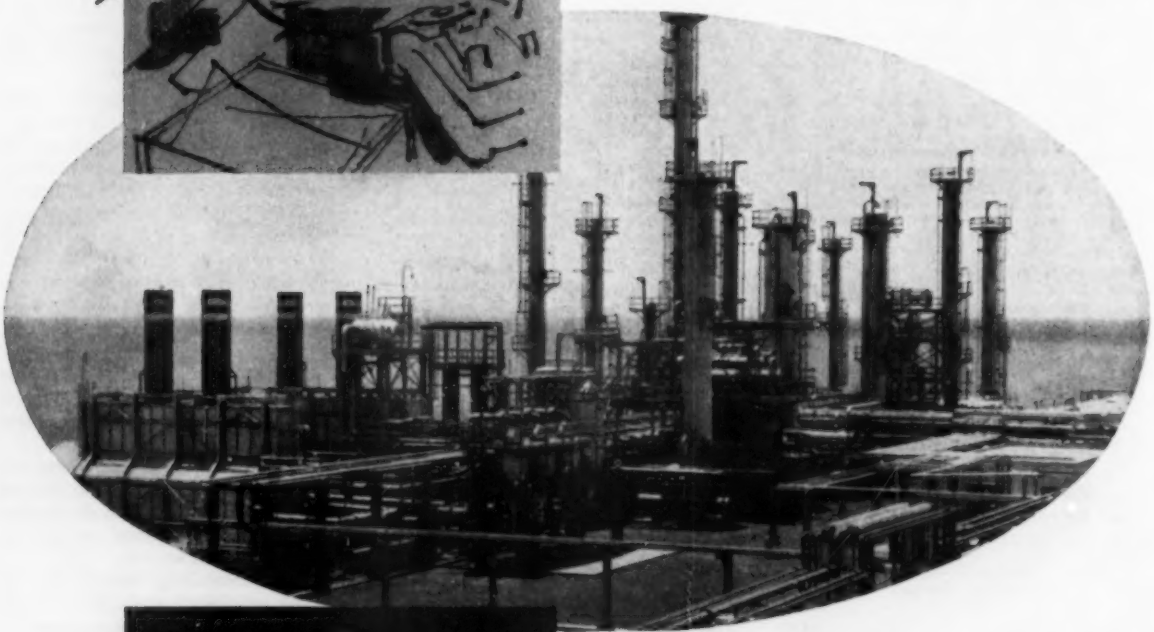

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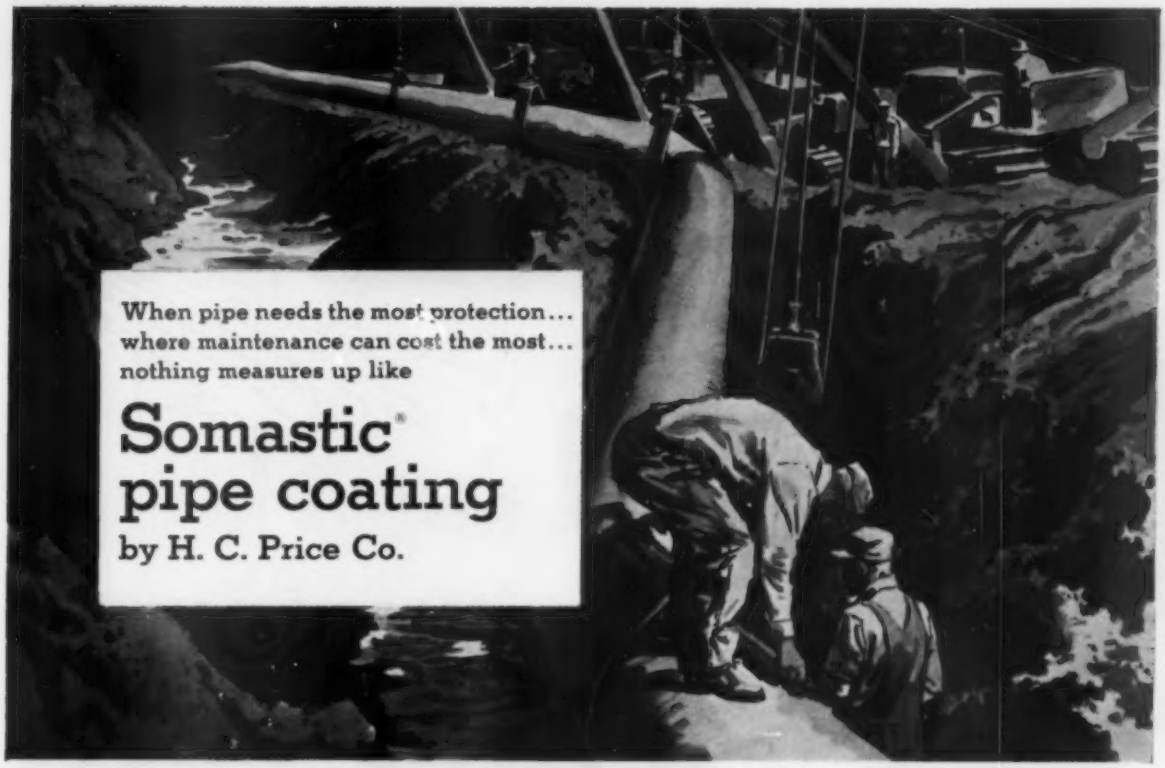
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HOW TO BE A MANAGER

Know Your Economics

Arnold E. Campbell

"There cannot any profit remain, if the cost exceeds the receipts." — Plautus. c. 190 B. C.

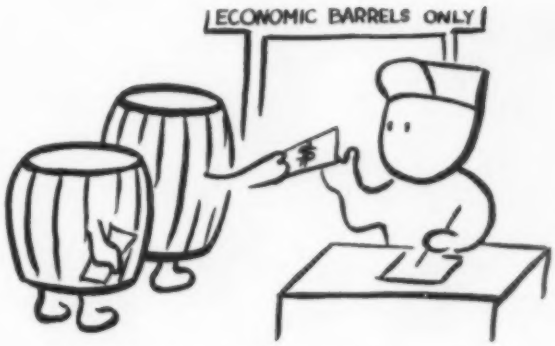
IF I WERE TO ASK: "How big is a barrel — an oilman's barrel?", you would probably answer, without hesitation: "Forty-two gallons." And you would, of course, be right — in a strictly physical sense. Again, if I were to ask: "Are all 42-gallon barrels the same size?", you would probably answer: "Yes." And once more you would be right — in a physical sense.

But suppose we look at our oilman's barrel from another angle, an economic angle. Then, paradoxically, all 42-gallon barrels are not the same size. We have $2.40 barrels, $2.80 barrels, $3.30 barrels, and so on. In this sense, in terms of the dollars each barrel represents, one 42-gallon barrel can conceivably be twice as large as another.

Now, let's project this concept of an "economic" barrel one step further. (And what we say about our barrel of oil applies equally well to a cubic foot of gas.) We might ask: "Are all $2.80 barrels the same size?" Considering only the money that they generate, we can justifiedly reply: "Yes." However, suppose we must spend $2.00 to acquire one $2.80 barrel and only $1.50 to acquire another $2.80 barrel. Then, economically, even these $2.80 42-gallon barrels are not the same size. And, if we must spend $3.00 to acquire a $2.80 barrel, it is not an "economic" barrel at all, but an "uneconomic" barrel — not an asset, but a liability.

For example, with reference to conservation, we continue to hear a great deal of talk, without qualification or reservation, about getting the final drop out of the ground, or squeezing the last barrel out of a reservoir.

We must always remember, however, that if we cannot realize a profit on that last barrel — if it is not an economic barrel — we are practicing waste, not conservation. The factors that we must keep uppermost in our minds at all times



Each barrel must pay its own way to remain an "economic barrel."

are income and cost, profit and loss, investment and rate of return — "economic" or "profit" barrels, not "physical" barrels. Because, no matter how many physical barrels we produce, unless we receive a resultant income in excess of the cost of acquisition, a net profit, our business cannot survive. "No one was ever ruined by taking a profit" is an old maxim of the stock exchange.

PROFITS ARE ESSENTIAL

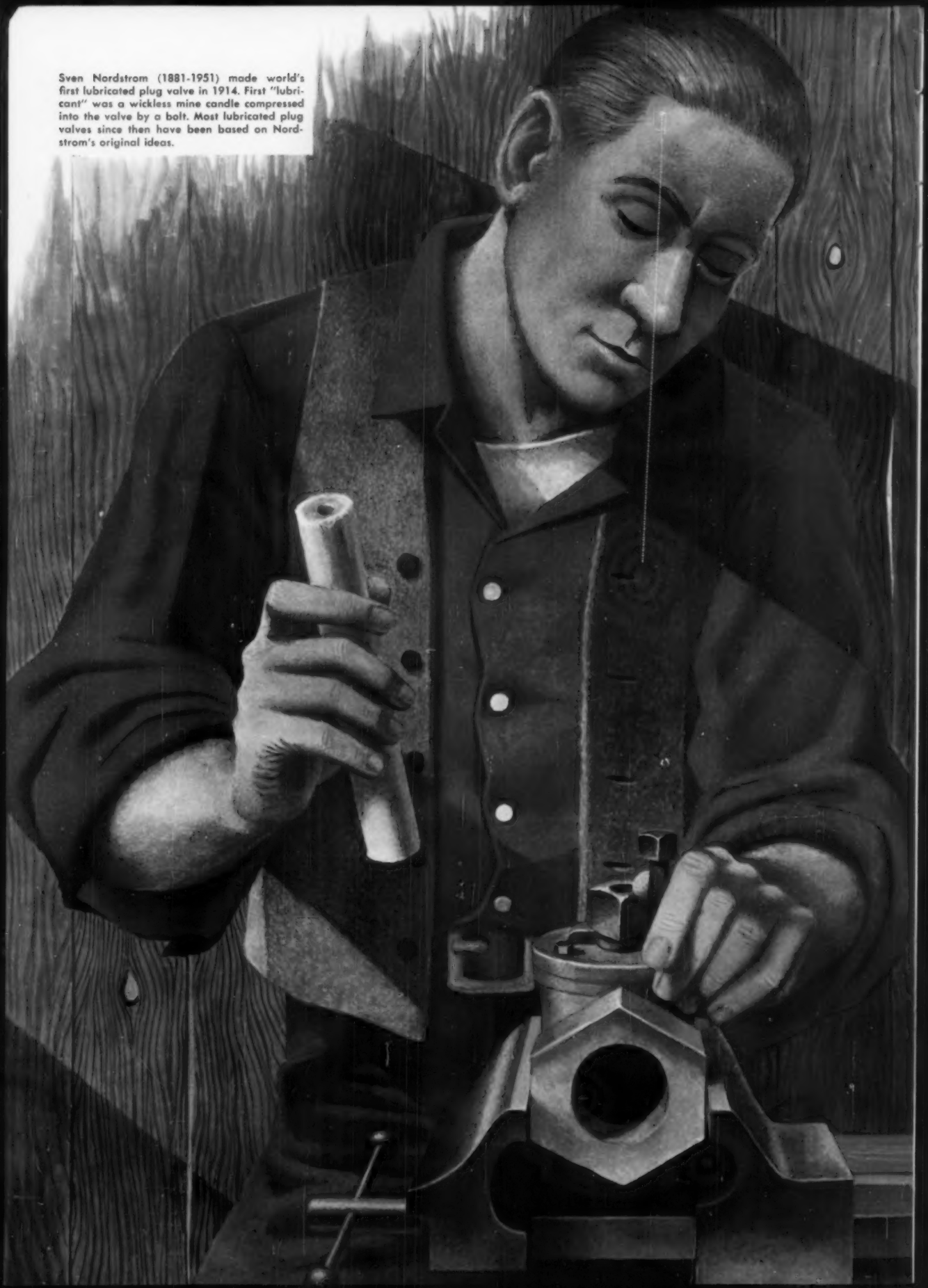
But, unfortunately, there are those, even within our own organizations, who would have us believe that making profits should be a minor aim of a business, subordinate to savings and retirement programs, group insurance and hospitalization plans, pleasant working environment, vacation and holiday schedules, and so on. We agree any business firm is vitally interested in such employee benefits and will contribute significantly and unselfishly to them. But the *main* function of the business is, nevertheless, profit-making. If it is not, the firm will expire. And these complementary benefits, no matter how desirable they are, will expire with it.

Still others would have us believe that making profits is somehow wicked and improper. And yet, we cannot deny that profit-seeking is the driving force of our free enterprise, capitalistic economy. It is the key, not only to business success, but to business survival. Sir Winston Churchill once wrote: "It is a socialist idea that making profits is a vice. The real vice is making losses."

A business firm (an oil company is a good example) is primarily a profit-seeking organization — not always profit-making, to be sure, but certainly always profit-seeking. And, over the long pull, if it is not profit-making as well, the organization cannot endure. It is as simple as that — profit or perish.

→

Arnold E. Campbell *is now a reservoir engineer for American Natural Gas Service Company, Houston, Texas. At the time of writing he was a senior staff engineer in the Economics and Evaluation Department of British-American Oil Production Company, Dallas, Texas. Alberta; received his BS in petroleum engineering from the University of Oklahoma in 1950 and immediately went to work for Shell Oil Company as an exploitation engineer in the United States and later in Canada. For five years prior to joining British-American in 1957 he was a staff petroleum engineer and a district engineer for Republic Natural Gas Company.*



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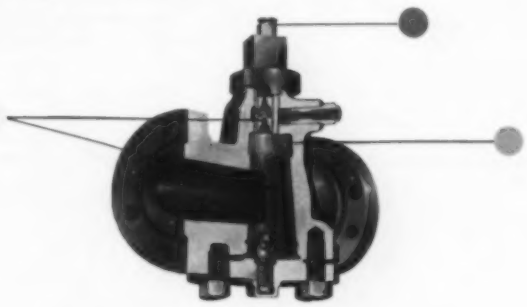

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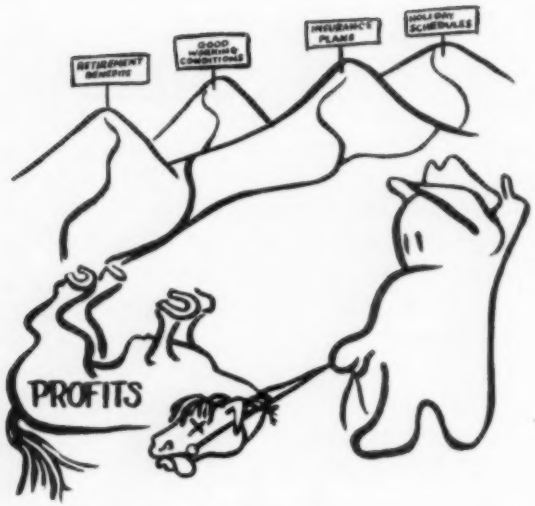
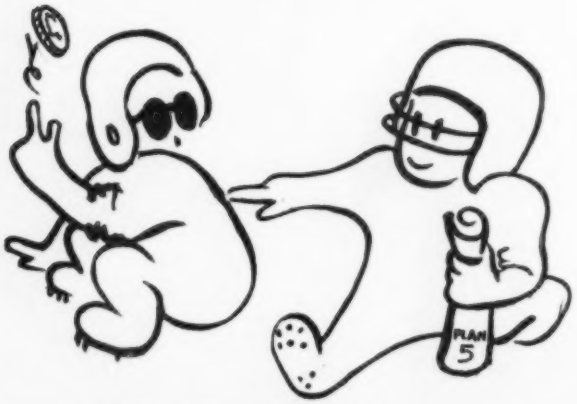


You can't make it to any of those goals on a dead horse!

Bennett S. Chapple, Jr., administrative vice president of U.S. Steel, puts it this way: *". . . recognizing that ours is a profit-and-loss economy and that all operations cannot be run at a profit all the time, we are always aware of the importance of profit in our business and in the economy as a whole. We have to live with the practical application of profit principles and understand that words alone do not automatically lead to black ink on the ledger of success. We know that the lack of profits, and of adequate profits, can snuff out the American dream."*

Based on the foregoing, we must conclude realistically that this drive for profit, maximum profit, is the basic motivation, the sine qua non, of the business firm. Unfortunately, in a glow of economic expansion, such as we have enjoyed since World War II, we are inclined to lose sight of this truth. But, during the last few years — since 1957 — this expansion glow has begun to fade a little.

Our record of sustained growth is beginning to waver somewhat erratically, ebbing and receding by turns. Continually increasing costs of labor and materials, despite a recession in rate of growth, are cutting drastically into profits and reducing profit margins. It is high time to readjust our sights, to intensify our profit-awareness, to evaluate our profit position more critically.



In our new position educated calculation must replace blind chance.

EVALUATING CAPITAL EXPENDITURES

The most important function of a manager, or an aspiring manager, at any level of organization, is to strive for maximum profitability. And, since profitability depends primarily upon efficient use of capital resources, we must become ever more selective in planning expenditures. By its very nature, this is a never-ending process, not a one-time decision, made and then forgotten. Additional funds are constantly being generated and these in turn must be reinvested profitably. This is a situation which has always been with us and, I guess, will always be with us. The following quotation points up this problem, with particular reference to drilling operations:

"It would be a disparagement to experience in this business to omit leaving a wide margin in our calculations for accidents. These are neither unfrequent nor trivial. With lawyer-like skill we should question and cross-question in respect to these liabilities. A tool breaks, or a piece of machinery, and everything stops but the wages of several men. *The charges for repairs is a separate item.*

"There are knotty questions touching the expense in this business, which nothing except experience can notice. A practiced workman to superintend the drilling is very desirable. He alone knows just what the work to be done

The manager must invest his capital toward the highest productivity.

is, and how to do it. He makes every move count, and the loss of time, money and labor is precluded. Not a few today would have less old iron to sell, and less broken pipe to raise from its grave, had they set to work those who understood it. The question is frequently asked, What has become of the money? *The truth is, in such ways as have been mentioned, especially under unskillful management and with much done at disadvantage, some wells have cost double and even treble what others have, equally deep.*

Count the cost. *Let the enterprise be viewed in all its liabilities. Instead of expecting to embark and float away at once on the tide to wealth, we do well to remember there are adverse currents to stem, storms to encounter and a reef to shun.—The noble ship, left to her unguided course, is a certain wreck; but with pilot, helmsman, chart, compass and a resolute, working crew, she stands a fair chance to bring home a precious cargo."*

Written last week? No, written 100 years ago, by Thomas A. Gale in his booklet, "Rock Oil, The Wonder of the Nineteenth Century," published in 1860, just one year after

the drilling of the famous Drake well, which heralded the birth of the oil industry.

Economically, the only justification for a capital expenditure is the expectation of a substantial profit. If the necessary profit is not forthcoming, the required investment funds will not be available in the future. And in the near future, we might add, if the current economic trends continue.

Along this line management consultant, Peter Drucker, in speaking of the next 10 years, posts this warning: *"There is going to be real competition for capital and a serious capital shortage. Private business will have to perform very well indeed to get the money it needs. The rate of profitability on which business now operates is too low to attract the capital it needs."*

Nowhere will this be more true than in the petroleum industry, where capital investment plays such a significant role in growth and prosperity. Here we deal with rapidly vanishing assets, which can be replenished only by huge capital expenditures, involving a high degree of risk, and, consequently, questionable profitability.

In no other major industry do capital expenditures bear such a high ratio to operating income. And, keeping in mind that, once made, expenditures cannot be retracted, but are committed for the life of the particular project, the need for accurate economic appraisals is apparent. Alternative investment possibilities must be compared on the basis of relative profitabilities, as a means of choosing among them and selecting the most advantageous.

In this respect, Robert G. Dunlop, president of Sun Oil Company, says: *"Management is constantly petitioned by operating people for funds with which to expand or improve capital facilities. Most of these suggestions are good, but they have the unhappy shortcoming of costing money, and in total may far exceed the company's resources. Obviously, then, management should choose those projects which, in the long run, promise to yield the greatest return on investment."*

Such selective planning and decision-making requires a sound understanding of basic economics, not only on a company or local level, but on a national and international level as well. More than ever before, to evaluate the comparative profitability of multiple proposals, the modern manager needs a broad background in economic analysis. To plan tomorrow's business, he needs a working knowledge of banking and finance, accounting and statistics, taxes and insurance, stocks and bonds, supply and demand, inflation and recession, materials and services, and so on.

With increasing emphasis on long-range planning and long-term investments, realistic business forecasts are imperative in estimating ultimate profitabilities. A successful manager must be ever mindful of the profound benefits of applying economic research and profitability analysis to minimizing the inherent risk in capital investment decisions.

Long ago, Louis Pasteur said: *"Chance favors the prepared mind."* So, let us be prepared to plan our capital expenditures more wisely, by adding to our economic knowledge at every opportunity.

To Decide on Capital Expenditures Ask Yourself

1. Is this expenditure necessary?
2. Is it necessary at this time?
3. Is it possible at this time?
4. Will it yield an ultimate profit?
5. Will it yield sufficient profit?
6. Is there a less expensive way to accomplish the same results?
7. What degree of risk is involved?
8. Would it be more profitable to invest these funds elsewhere?
9. Would there be less risk in investing elsewhere?
10. How long will it take to recover the investment?

Under the good manager's hat are many experts.

11. Was this expenditure anticipated in previous planning?
12. Will it influence future planning?

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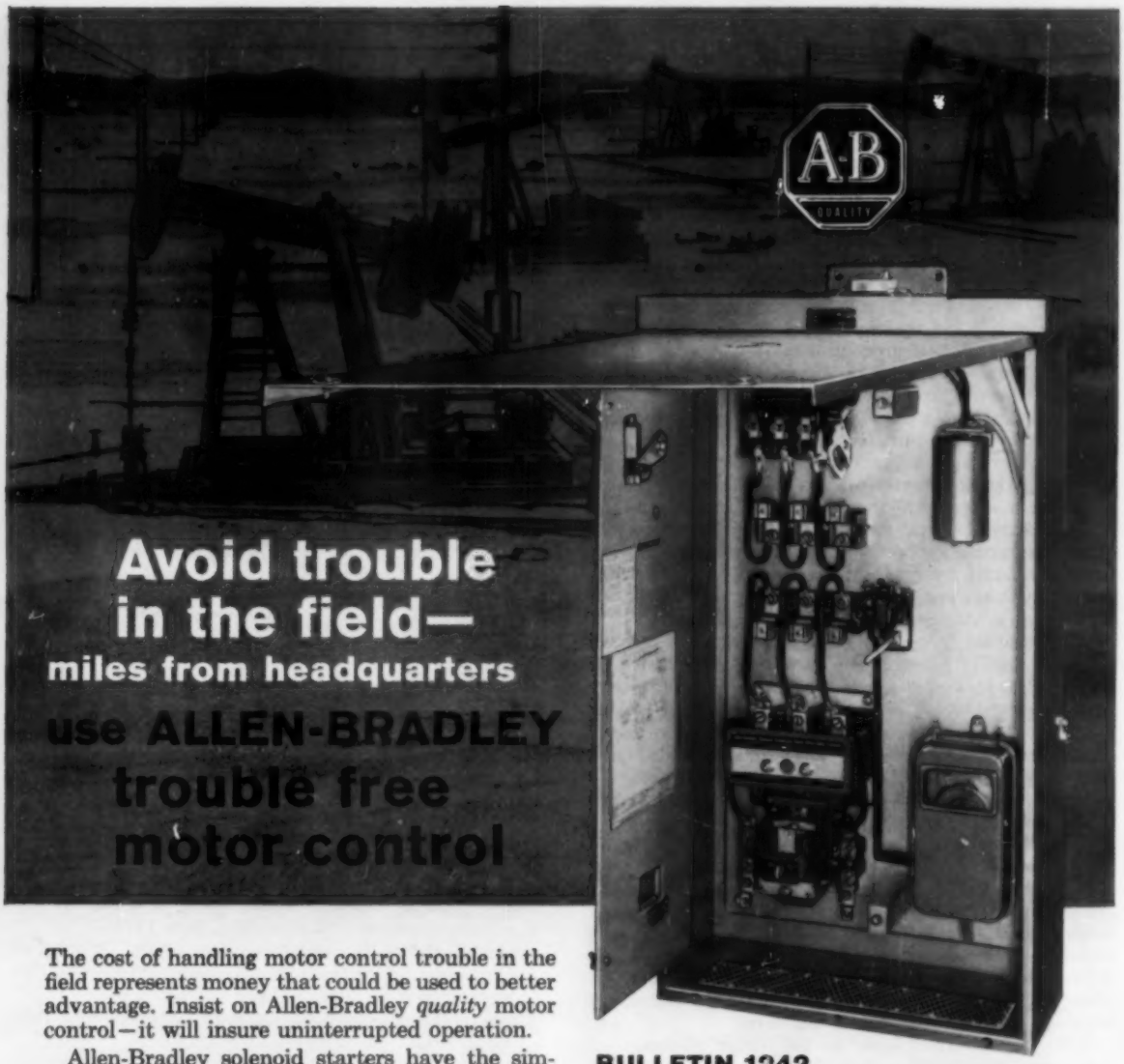

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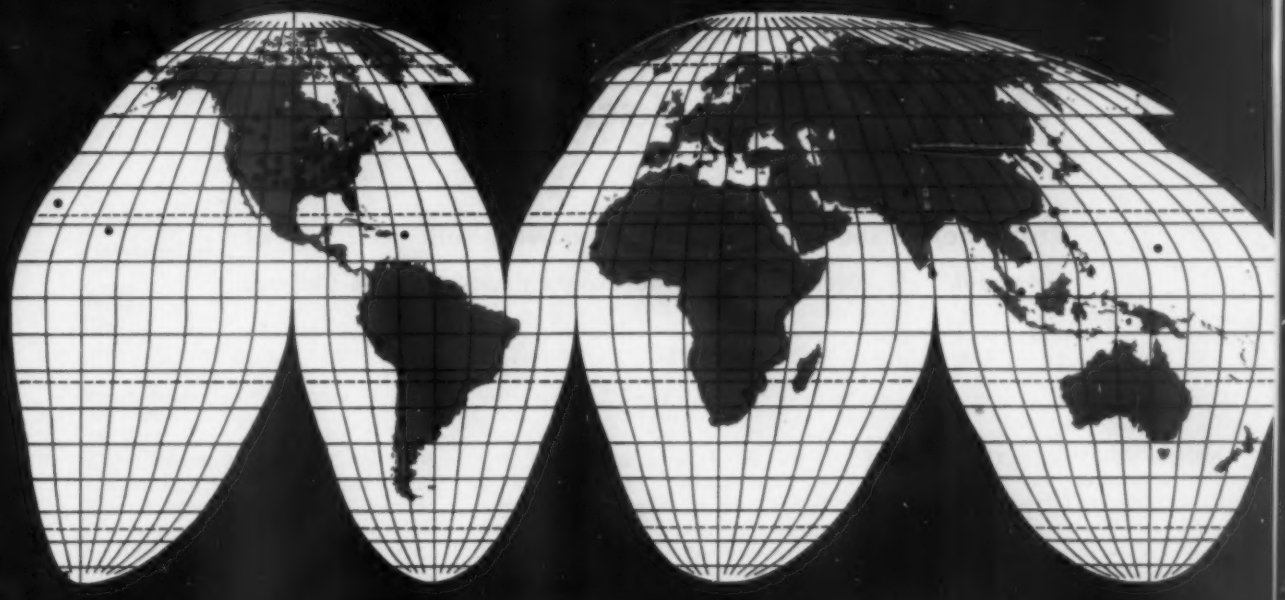

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Only 24% of the listed companies had a decrease in earnings for the third quarter.

Revenues held to a steady 3% rise for the third quarter as well as for the first three quarters.

The petroleum industry stood out as one of the bright spots for industry earnings in the third quarter. The First National City Bank of New York found the increase 8% for 764 companies. Earnings for the first nine months for this same group decreased by 2%.

Here are some of the reasons given for the good showing of the industry:

Tidewater Oil. With highest earnings in history, both for third and three quarters periods, the record earnings were said to represent benefits from substantial capital rebuilding program and from concerted efforts of management to better the company's operating efficiency and competitive position.

Delhi-Taylor. Natural gas sales and petrochemical sales each increased by 8% in the first nine months of 1960 over the same period of 1959.

Continental Oil. Factors contributing to improvement in earnings during the third quarter include: A high level of prices for certain refined products, increased receipts from operations, lower intangible development costs, a smaller provision for possible loss on foreign investments, smaller provision for federal income taxes.

Standard of Ohio. Increased sales of premium gasoline, efficiencies of new facilities and other cost reductions brought 42% earnings increase, with only 7% increase in sales for the third quarter.

Ambassador Oil. Able to increase its oil and gas sales by 21% despite a 20% decrease in Texas producing days.

Atlantic Refining. Increase of 30% in third quarter was attributed to higher crude oil sales, somewhat better product prices and lower payroll costs.

Standard of California. Domestic gains were primarily the result of improved product sales, and of higher sales of industrial and agricultural chemicals. In addition crude production was up significantly from onshore and offshore fields in Louisiana.

Colorado Oil and Gas. Sharp improvement was caused principally by stable and generally firmer prices for refined products. This company had the highest earnings for the third quarter of any quarter in its history.

Gulf. Principal reasons for increase were higher domestic production of crude oil and natural gas and higher levels of petrochemical sales in the U. S.

Texaco. Operations during the nine months continued at a high level. Dividends from domestic and foreign affiliates were greater than in the same period last year. This together with careful control of expenses enabled the company to increase earnings.

Ocean Drilling and Exploration. This company ran contrary to the general fall-off in contract drilling. It had a substantial increase in revenue from contract drilling and began its first significant income from oil and gas production.

Union Oil of California. Natural gas sales played an important part in higher revenues and earnings. First nine months gas sales reached an all-time high record, 35% above last year.

Shell Oil. Improved earnings reflected higher prices in many areas for petroleum products and an increase in sales of natural gas. Cutting into net somewhat were higher exploration expenses and costs related to initial operation of several new plants.

British American. Production of natural gas in the United States is running at the highest rate in the history of B-A Oil Producing Company—17% higher than in 1959.

Standard Oil (New Jersey). The 5% improvement in earnings was due largely to substantial rise in petroleum product sales worldwide, as well as volume gains for petrochemicals and natural gas sales in the United States. This improvement in sales, together with further operating efficiencies, more than offset the impact of lower crude and product prices caused by strong competition in Jersey's markets.

Sun Oil. Sharp 46% gain in the third quarter was due to: Restricted drilling programs, increased volume of natural gas sales, improved operating efficiencies and somewhat better prices for petroleum products.

Sinclair. Some of the improvement was derived from better product prices, but much of the increase was the result of direct and aggressive action by management.

Skelly. Substantial gain in third quarter was due to production of crude oil exceeding that of 1959. Restriction of production in this three months period was the most severe in several years, but increase came from a successful drilling program and secondary recovery operations.

Phillips. Better profits resulted from new diversified projects, particularly in chemicals and natural gas liquids.

Cosden Petroleum. Refining and marketing of petrochemicals will account for 20% of profits this year, it is estimated. Earnings are down because of price wars which cut dollar sales of gasoline in the retail outlets.

More significant than general increases was the encouraging signs of improving profit margins. In the third quarter earnings went to 8.6% of revenues this year. In 1959 it was only 7.6%. This is the best sign of more efficient operations. Back in 1956 earnings were 10.7% of total income and the margin has been eroding ever since.

—Ernestine Adams

TABLE 1. PETROLEUM INDUSTRY FINANCIAL REPORTS FOR FIRST NINE MONTHS.

Company	Third Quarter Gross ($1000) 1959	1960	% Change	Third Quarter Net ($1000) 1959	1960	% Change	Nine Months Gross ($1000) 1959	1960	% Change	Nine Months Net ($1000) 1959	1960	% Change
Ambassador	1,632	1,610	— 1	198	270	+ 36	4,210	4,888	+ 16	378	964	+155
Amerada	24,107	24,240	+ 1	5,902	5,959	+ 1	76,633	76,068	— 1	17,563	18,018	+ 3
Anderson-Prichard	18,722	19,252	+ 3	1,823	1,697	— 7	54,509	55,870	+ 2	4,867	3,863	— 21
Argo	3,610	3,946	+ 9	1,054	1,249	+ 19	10,674	11,238	+ 5	3,685	3,692	
Ashland	72,077	73,719	+ 2	3,817	4,998	+ 24	224,676	223,494	— 1	11,117	11,300	+ 2
Atlantic	124,664	133,456	+ 7	8,073	10,488	+ 30	404,631	414,034	+ 2	25,429	27,405	+ 8
Aztec	2,200	1,862	— 15	1,405	1,000	— 29	6,142	6,029	— 2	3,956	3,443	— 13
Bishop	422	473	+ 12	(669)	32	+105	1,382	1,467	+ 6	(20)	85	+525
British American	—	—	—	6,689	7,527	+ 13	—	—	—	15,085	21,257	+ 41
Champlin O & R	21,005	22,739	+ 8	1,857	2,786	+ 50	63,801	63,829	—	6,144	6,148	0
Cities Service	—	—	—	8,396	7,865	— 6	—	—	—	27,301	26,538	— 3
Clark O & R	22,637	20,661	— 9	915	794	— 13	63,821	62,755	— 2	1,921	1,002	— 48
Coastal States[1]	—	—	—	—	—	—	10,354	17,586	+ 70	1,586	2,951	+ 86
Colorado O & G	12,287	11,661	— 5	731	952	+ 30	34,201	34,248	—	1,765	638	— 64
Commonwealth Oil	19,119	22,589	+ 18	1,028	2,619	+155	49,820	56,509	+ 13	901	3,667	+307
Continental Oil	204,047	201,687	— 1	16,170	16,942	+ 5	587,840	597,087	+ 2	45,330	45,435	0
Cosden	23,517	22,493	— 4	1,438	1,381	— 3	64,701	61,349	— 5	3,834	3,006	— 22
Crescent	4,922	5,330	+ 8	379	463	+ 22	15,943	16,500	+ 3	1,761	1,879	+ 7
Delhi-Taylor	21,600	23,200	+ 7	1,280	900	— 30[6]	64,550	70,500	+ 9	2,730	3,050	+ 12[6]
Douglas of Calif.	—	—	—	—	—	—	16,465	17,671	+ 7	522	597	+ 14
Essen[9]	—	—	—	—	—	—	3,764	3,709	— 1	337	222	— 34
Frontier	12,037	12,766	+ 6	351	726	+106	24,540	31,526	+ 28	591	1,409	+138
General American[1]	6,445	7,694	+ 19	1,107	1,582	+ 43	25,789	27,958	+ 8	6,696	2,261	— 66
Getty Oil	11,106	11,058	0	1,586	1,796	+ 13	32,275	32,299	0	5,881	6,286	+ 7
Gulf	—	—	—	74,661	81,814	+ 10	—	—	—	216,475	237,910	+ 10
Husky Oil[1]	—	—	—	—	—	—	29,410	28,404	— 3	878	(280)	—
Kerr-McGee[1]	—	—	—	1,461[4]	4,011[4]	+176	134,165	157,785	+ 18	5,873	7,287	+ 24
Leonard	13,216	14,503	+ 9	447	610	+ 36	41,103	41,286	—	1,065	1,378	+ 29
Louisiana Land & Expl	10,055	11,571	+ 15	4,968	6,040	+ 22	28,310	33,721	+ 19	14,136	17,102	+ 21
Maracaibo	110	79	— 28	55	39	— 29	365	316	— 13	193	157	— 19
Midwest Oil	4,953	5,223	+ 5	1,493	1,500	0	15,497	15,291	1	4,964	4,899	— 1
Murphy Corp.[2]	12,691	15,374	+ 21	855	876	+ 2	37,668	44,970	+ 19	2,692	2,784	+ 4
Ocean Drlg. & Expl.[2]	1,746	2,148	+ 23	8	464	+5700	4,674	6,113	+ 31	(87)	737	—
Ohio Oil	115,316	87,143	— 24	8,854	9,590	+ 8	259,306	263,116	+ 1	27,323	27,410	+ 1
Olin Oil & Gas	10,301	11,421	+ 11	922	1,029	+ 12	30,999	34,972	+ 13	2,997	2,604	— 13
Phillips	284,489	299,274	+ 5	24,177	27,172	+ 12	882,048	902,373	+ 2	77,386	78,920	+ 2
Plymouth	20,515	16,829	— 18	611	(342)	—	69,071	57,941	— 16	2,795	(299)	—
Pure	153,628	158,879	+ 3	6,094	6,457	+ 6	461,758	487,331	+ 6	19,242	20,213	+ 5
Quaker State	13,537	13,962	+ 3	759	595	— 21	41,406	40,349	— 2	1,763	1,361	— 22
Richfield	70,966	75,908	+ 7	7,494	6,788	— 9	203,381	213,939	+ 5	18,189	20,776	+ 14
Shamrock[2]	15,143	17,036	+ 13	2,163	2,743	+ 27	43,414	49,050	+ 13	6,949	7,203	+ 4
Shell	455,551	458,383	+ 1	34,868	34,996	0	1,354,434	1,362,324	+ 1	104,055	104,308	0
Signal	34,928	79,769	+128	3,866	4,356	+ 13	115,058	231,649	+101	12,525	11,960	— 5
Sinclair	287,492	280,646	— 2	7,971	12,842	+ 61	915,109	903,606	— 1	34,571	34,504	0
Skelly	61,006	63,322	+ 4	5,153	6,033	+ 17	192,121	187,789	— 2	19,110	17,122	— 10
Socony Mobil	—	—	—	45,900	52,500	+ 14	—	—	—	123,000	135,900	+ 10
Standard (Calif.)	495,738	548,343	+ 11	61,962	70,666	+ 14	1,414,870	1,529,053	+ 8	180,115	199,255	+ 11
Standard (Ind.)	495,540	508,017	+ 3	27,338	37,939	+ 39	1,492,577	1,508,333	+ 1	106,189	102,826	— 3
Standard (N.J.)	2,240,000	2,275,000	+ 2	162,000	186,000	+ 15	6,495,000	6,592,000	+ 1	477,000	501,000	+ 5
Standard (Ohio)	96,048	102,729	+ 7	4,670	6,618	+ 42	296,661	297,501	—	14,550	17,574	+ 21
Sun	182,150	181,207	— 1	10,177	14,820	+ 46	567,465	548,007	— 3	32,151	34,852	+ 8
Sunray Mid-Cont.	112,620	116,589	+ 3	9,835	10,335	+ 5	341,045	344,692	+ 1	30,783	29,078	— 6
Superior Oil[5]	—	—	—	(3,615)	3,052	+ —	131,917	130,534	— 1	19,356	21,602	+ 12
Texaco	—	—	—	96,893	101,642	+ 5	2,092,618	2,306,229	—	261,854	278,984	+ 7
Three States Natural Gas[7]	—	—	—	—	—	—	5,374	5,120	— 5	(207)	593	—
Texas Pacific	6,385	6,445	+ 1	1,541	1,791	+ 16	19,600	19,691	0	5,183	5,759	+ 11
Tidewater	137,057	146,952	+ 7	9,199	13,074	+ 42	415,473	434,681	+ 5	27,832	31,351	+ 13
TXL	3,100	2,922	— 6	913	566	— 38	10,010	9,431	— 6	3,156	1,956	— 38
Union Oil of Calif.	131,767	140,503	+ 7	9,129	10,352	+ 13	381,674	401,175	+ 5	19,900	23,721	+ 19
Universal Consol.	2,020	1,839	— 9	695	653	— 6	6,193	5,593	— 10	2,593	1,880	— 28
Wilcox	1,776	1,562	— 9	246	133	— 46	5,582	4,392	— 21	668	579	— 8
TOTALS	6,085,801	6,253,216	+ 3	687,938	790,143	+ 15	18,283,023	18,779,201	+ 3	2,066,577	2,180,082	+ 6

[1] Fiscal year ending June 30.
[2] 3rd quarter ending August 31.
[3] Three months ending August 31.
[4] 1st fiscal quarter ending September 30.
[5] Six months ending September 30.
[6] These figures include sales of capital assets. Percentage change for earnings outside these sales are —15% for third quarter; +72% for nine months.
[7] Fiscal year ending May 31.
[8] Fiscal year ending August 31.
[9] Fiscal year ending July 31.
[10] Excluding sales of subsidiary acquired during 1960.

MOTIVATING SUBORDINATES

D. ROBERT YARNALL, JR.*

TO ACHIEVE THE RESULTS for which he is held accountable, any manager must plan, organize, motivate, and measure results. How can the modern manager bring out the best performance from subordinates whose physiological and security needs are largely satisfied and who are not strongly motivated by fear of poverty or serious deprivation? Drawing on his own experience in managing a high-quality metal manufacturing plant, the author describes a series of managerial attitudes and actions which appear to be very effective in motivating subordinates to high performance.

ONLY ONE PERSON out of five worked for somebody else in this country one hundred years ago. The other 4 out of 5 were predominately independent farmers, shopkeepers, professionals, and craftsmen. Now, only one hundred years later, that ratio has been reversed and 4 out of 5 of us work for somebody else! This means that the supervisor-subordinate relationship is a basic aspect of human experience in our highly organized, industrial society. The nature of this relationship is of profound importance to the individuals involved and to the results they achieve in their work.

*Mr. Yarnall, vice president, manufacturing, Yarnall-Waring Company, Philadelphia, Pa., presented this paper at the Summer Annual Meeting, Dallas, Texas, June 5-9, 1960, of The American Society of Mechanical Engineers.

Lawrence Appley, president of American Management Association has written: "The most vital spot in management is the point of contact between worker and boss. The focal point, the point of greatest return, is the relationship that exists from day to day between the supervisor and the supervised on all organizational levels. Making this relationship constructive and productive merits more attention than any other management activity." Notice that Mr. Appley said "*the point of greatest return*" is the relationship between supervisor and supervised. This isn't sentimentality. He's talking in terms of *results*—in terms of *effectiveness*. This may sound obvious, but let's take a minute to explore why it is true.

The point of contact is the focal point.

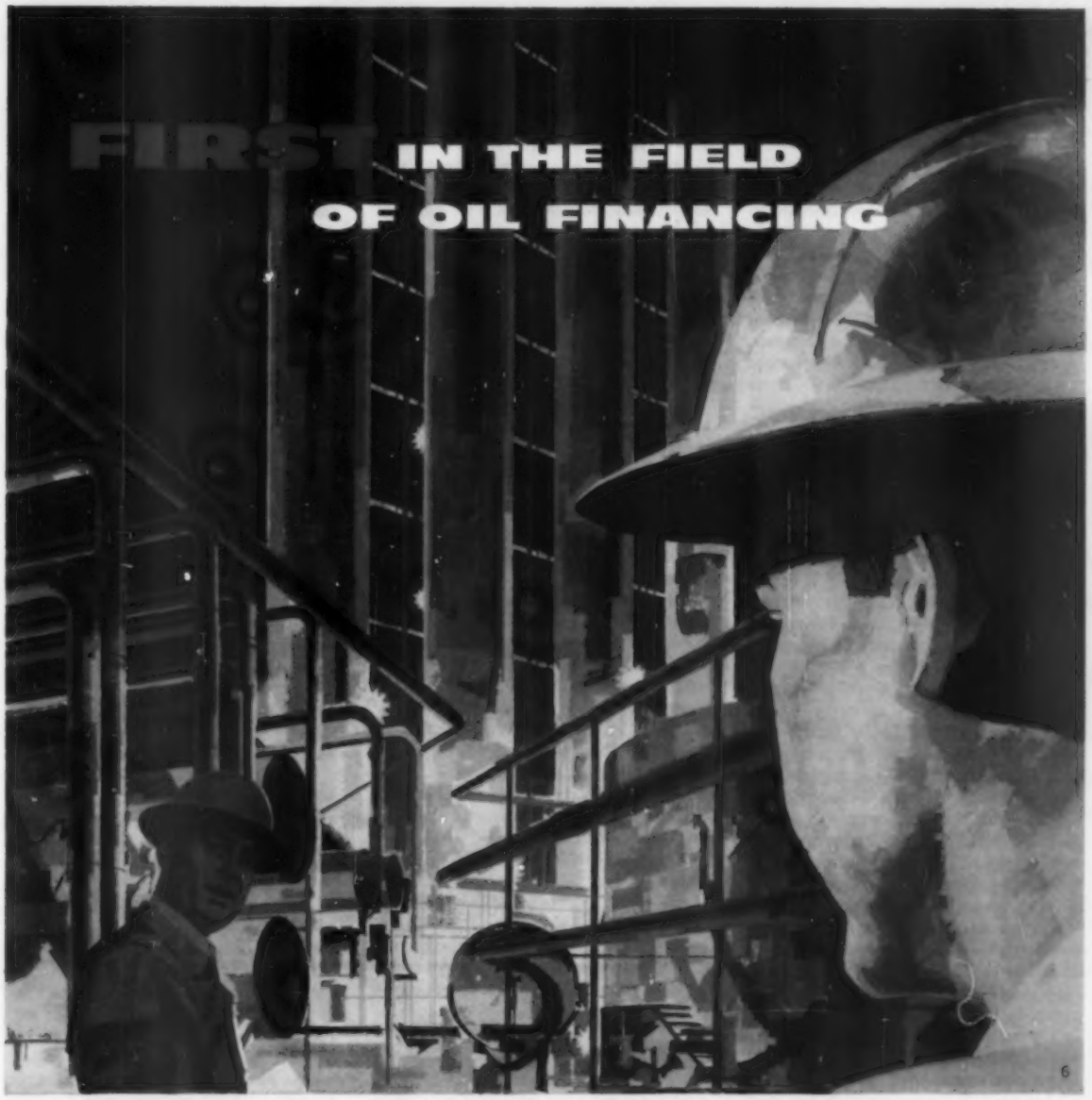
The Boss is accountable to *his* Boss for *results*. He must achieve these results through the work of other people, the people whom he supervises. Whether the results (and hence the Boss's performance) are good, bad, or indifferent will depend on whether the work of his subordinates is good, bad, or indifferent. And, in my experience at least, the greatest single factor determining whether the subordinate's work is good, bad, or indifferent is the quality of the relationship which exists between them and the Boss.

Please don't jump quickly to the conclusion that I will then go on to say that, therefore, all the Boss has to do is keep everybody happy, satisfy their every whim, and things will really begin to hum. Certainly not. Harmony and contentment, of themselves, do not and cannot assure productivity. Nor will I suggest that there is some convenient "human relations gimmick" which will serve as a successful substitute for job competence, operating knowhow, and sound strategic decisions on the part of both the Boss and his subordinates. There is not. At least if there is, I've never heard of it!

Plan, Organize, Motivate

No, there aren't any shortcuts. In setting out to achieve the results for which he is accountable, the Boss must do four things, all of which are important. He must plan. He must organize. He must motivate, and he must measure results. Let's look at each of these functions in a little more detail.

First of all, he must develop a plan to achieve the desired results, starting



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with a clear understanding of the objectives and how he's going to get there. This will include such things as basic strategy, a timetable, and an estimate of the people, money, materials, equipment and other resources which will be required to reach the objectives.

He then must organize a group of people capable of reaching the objective. This requires careful analysis to develop a clear statement of the basic qualifications — physical, mental, and special training — which the people must have to start with. He then must recruit and select people who possess those qualifications. As I stated earlier, there is no "human relations" substitute for having people who possess the basic job competence which is required—let's call it the "can do."

Our Boss has now developed his basic plan and he has set up an organization of people who have the necessary qualifications — who "can do." The next step is to see to it that those people are motivated to reach the objectives — that they are provided with the necessary "will do." The dictionary defines "motivate" as "to impel, to incite into action," and that's exactly what we're talking about.

Measure Results

Last but not least in our breakdown of the Boss's activities is the measurement of results. It is obviously important to him, to his Boss, and to his subordinates that this part of the job be well done. It may take the form of balance sheets and profit and loss statements, or performance against a budget or sales quota, or it may involve physical tests, or some sort of sampling, or perhaps the results of a questionnaire of some kind. The important thing is that the factors selected should be relevant to the results desired, that they are actually subject to reliable measurement by the means available, and that they are understood by the people whose work is being measured.

Planning, organizing, motivating, and *measuring results* — each is essential, and each comprises a deep and fascinating aspect of management action about which volumes have been written. Without minimizing the importance of the other three, however, I am going to suggest that the Boss's success in motivating — in stimulating the "will do" in his people — will produce the greatest rewards in results over and above that which just "gets by." And this margin is often the make-or-break margin, the succeed-or-fail margin in our highly competitive world. There is a tremendous difference between results which are just adequate and the best results which a person or a group of people is capable of producing—which they "can do." And the more advanced our technology, the wider the range becomes; compare, for example, the range of potential performance in digging a ditch with that in programming a computer.

How Are We Motivated?

If motivation is so important, how then is human effort to be motivated toward realizing the highest objectives of the organization? To answer this we will have to seek the help of the psychologists. They tell us that man's behavior, at work and elsewhere, is the result of his effort to satisfy certain basic needs. As soon as one of his needs is satisfied it is no longer a motivator of behavior and another appears in its place. They also tell us that man's needs are arranged in an hierarchy of importance. At the bottom of the list are his physiological needs for such things as food, shelter, clothing, rest, and exercise. These needs are preeminent when they are unsatisfied. Man does live by bread alone when there is no bread!

At the next level are the safety needs for protection against danger, and deprivation. Fear is a powerful motivator of behavior when this need is unsatisfied.

When man's physiological needs and safety needs are reasonably satisfied, his social needs become significant motivators of his behavior. These are his needs for belonging, for acceptance by his fellows, for giving and receiving love and friendship.

Above these social needs are the so-called ego needs which include the needs for status, for respect, for recognition, for self-esteem, and for independence. Unlike the lower needs, these are not often satisfied, and they do not become operative in any significant way until the physiological, safety, and social needs have been reasonably satisfied.

Highest in the hierarchy of man's needs are what might be called the need for self-fulfillment. These include the need for realizing one's highest potential, for being creative in the broadest sense, for deepening religious, artistic, and intellectual insights, and for developing truly mature relationships with others.

In an earlier day the Boss usually motivated his people with threats and/or promises of reward which were largely aimed at satisfying their physiological and safety needs. This worked so long as men struggled for subsistence and lived in constant fear of unemployment, but it is not nearly so effective in a happier society where most men have reached an adequate subsistence and safety level, and hence, are motivated primarily by higher needs. Today's Boss must therefore acquire real understanding of the social, ego, and self-fulfillment needs of his people if he is to understand what may motivate them to the highest levels of performance.

Where will such understanding lead in determining the attitudes and actions of the Boss which will be most effective in getting high performance from his subordinates?

Add the best attitudes of management . . .

The Boss's Attitudes

Let's first talk about his attitudes. In my experience the Boss who is most effective in getting really good results is likely to have the following attitudes toward people and toward work.

1. **He has faith** in other people. He believes that most people are basically good, that they want to do the right thing, and that they are fundamentally trustworthy, at least until proven otherwise. He has come to recognize that people respond favorably to evidences of genuine trust in them.

2. **He believes** that people should be viewed as ends in themselves rather than as means. Instead of wielding power over other people, he prefers to

use power in working with people. He inclines toward developing associative relationships with his people — associated together in a common undertaking rather than an arms-length, master-servant relationship.

3. **In thinking** of the growth and development of his subordinates, he tends to think in terms of providing them with opportunities and encouragement for self-development rather than trying to mold them in his own or some other preconceived image. (I once heard someone point out that the word "educate" comes from the Latin meaning "to draw out" — which is quite different from the "stuff down" approach we so often follow!)

4. **He has understanding** and deep respect for the rights of every person in the organization, and he probably agrees with the following statement of those rights which was written by Ordway Tead in his book "The Art of Administration":

"(a) The right of every man in the organization to be treated as an individual and respected as a person.

"(b) The right of every man in the organization to a voice in his own affairs, which includes his right to contribute to the best of his ability in the solution of common problems.

"(c) The right of every man in the organization to recognition for his contribution to the common good.

"(d) The right of every man in the organization to develop and make use of his highest capabilities.

"(e) The right of every man in the organization to fairness and justice in all his relationships with superiors."

Is this a naive view of the attitudes to be expected in an effective boss? Perhaps it is. Obviously, it is drawn from a view of the nature of man which is not shared by everyone. I can only say that in my experience managers who have had this kind of attitude toward people and work have been the most effective managers in terms of achieving real results.

But you're probably saying to yourselves, "all this stuff about attitudes is all very well, but so what? You have to have more than attitudes to cut the mustard!" I agree. So let's turn then from the Boss's attitudes to the kinds of action which grow out of those attitudes.

The Boss's Actions

I submit that the Boss who is most effective in getting best results through motivating his subordinates to high performance is likely to act somewhat as follows:

1. *He thinks* and talks and acts in terms of "management by objective" rather than "management by direction and control." He is more interested in results—excellent results—than in controlling the precise methods used by his subordinates.

2. *He invites* his subordinates to participate in establishing their work objectives within the over-all objectives for which he is responsible. He has found that this practice improves the understanding and acceptance of the objectives and gives the subordinate a real stake in the outcome.

3. *He understands* clearly that this sharing of responsibility does not in any way relieve him of the ultimate accountability for over-all results. He sees to it that each of his subordinates understands clearly at all times the results for which he is accountable.

4. *He tries to provide* each subordinate with the resources and authority (which might better be called freedom to act) which are required to get the results for which he is responsible.

5. *He makes clear* to his subordinates the boundaries, pitfalls, and guiding policies within which they must act.

6. *He is sensitive* to the uniqueness of individuals and has discovered that each of his subordinates is a completely different person. He also tries to be sensitive to his own impact on his subordinates.

7. *He demonstrates* real confidence in his subordinates and makes them realize that he wants them to succeed!

8. *He is sincere*, consistent, and absolutely honest in all his dealings.

9. *He makes a real effort* to keep his subordinates fully informed — not only on matters related to their immediate responsibilities but also the general background information which will help them to understand their role as part of a larger undertaking.

10. *He encourages teamwork* and cooperation among his subordinates, making it clear that he expects them to work together to resolve their differences and solve common problems.

11. *He realizes* that new ideas are fragile! He is careful never to ridicule any idea advanced by a subordinate, having learned that the good ones don't necessarily come first.

. . . and the resulting actions will produce a winning combination.

12. *When things* aren't going as they should, he tends to take a problem-solving approach directed toward remedial action, rather than going out head hunting.

13. *He doesn't freeze* his subordinates with fear of making a mistake, or fear of admitting that they have done so. He expects them to learn from their mistakes, and not to let the same one happen twice.

14. *He makes sure* that his subordinates understand the methods being used to measure their performance and he invites their participation in measuring the results they are obtaining.

Try to Practice

We have tried to spell out a partial description of the man who will be the most effective Boss in the years ahead — partial in that it deals only with his attitudes toward people and work and with the kinds of action he takes to motivate his organization. At the outset we recognized that motivating is only part of the Boss's job — he must also work steadily and effectively at planning, organizing, and measuring results. The managerial attitudes and actions presented here are not a substitute for doing these tasks well — on the contrary, we can expect that genuine success in releasing the talents and energies of subordinates will require more planning, better organizing, and more accurate measurement of results than ever before.

I am not for one minute suggesting that we in our company have developed this approach to its fullest. It would be folly for me to make such a statement if only because there are too many of my associates who might be tempted to quote Emerson when he said "what you are thunders so loud that I cannot hear what you say." We are trying, however, along with many others to evolve and put into practice an ever more effective philosophy of management. Obviously, we must be practical — whatever we do has to work, it has to get results.

It would be comfortable if we could just rely on what worked yesterday, but unfortunately it's not that simple in our rapidly changing industrial society. "What was good enough for Granpappy" isn't any better today in the management field than it is in the design of a refrigerator or an airplane.

It behooves us all, therefore, as engineers, as businessmen, and as citizens, to spend at least some of our creative thinking on this intriguing and potentially rewarding subject of motivating subordinates to high performance. ★

Deep Drilling Increases Outside USA

Number of wells below 15,000 ft goes up yearly.

ERNESTINE ADAMS

HOW MANY DEEP WELLS have been drilled in the Free World outside of the United States? Don't look at the table, just take a guess. You wouldn't have thought there were 33. There may be more, but the records are hard to find. The first 15,000 ft well outside of the United States was drilled by Shell in Venezuela in 1931.

Venezuela is by far the most popular place for deep drill. It has 22 wells below 15,000 ft.* Canada comes next with 3 deep wells and Colombia and Spain each has 2. In four other countries there is one deep well — France, Barbados, Bolivia and the Bahamas.

Deepest well outside the United States is the one drilled in the Bahamas by subsidiaries of Gulf Oil and Standard of California. It went to 18,906 ft. This may also be the most expensive. It is reputed to have cost some $3 million besides the expensive preliminary work before a location was made.

It is difficult to say with any certainty how many wells Russia has below the 15,000-ft depth. The only one on which we have any data is a well in the Baku which went to 15,880 ft. There are a number of articles in Russian news reports about deep wells, but seldom does this include the actual depth of the well.

It is easily possible that we have missed some deep wells in the Free World and if you know of any we'd like to hear about them to keep the record straight.

Gulf or its subsidiary (Mene Grande) has drilled 11 deep wells outside the U.S. Shell comes next with 5. Standard of California has 4, Esso and its subsidiaries 3, and Mobil 2.

Beginning in 1931 one deep well was drilled in 1950, 1953, 1954, 1955, two in 1956 and one in 1957. Then deep drilling picked up and there were 5 in 1958, 11 in 1959 and so far this year, counting one drilling, there are nine.

* * *

*This information came from Francisco Alvarez Chacin, acting manager, public relations department of Creole Petroleum Corporation. It's a pretty impressive list.

WELLS BELOW 15,000 FT OUTSIDE U.S.A.

Country	Company	Well	Location	Date Completed	Depth Ft.	Remarks
Barbados	Gulf-Kerr McGee	Lewis No. 1	Scotland Dist.	1959	15,077	D & A
Venezuela	Mene Grande	75-Y-4X	Zulia	1960	15,081	D & A
France			Lacq Field	—	15,100	
Venezuela	Shell	Curacao 2-A	Zulia	7/11/31	15,106	D & A
Venezuela	Mobil	Largo 1	Anzoategui	12/31/58	15,108	Producer.
Venezuela	Mene Grande	75-Z-12X	Zulia	9/23/59	15,124	Suspended.
Canada	British Am. et al	LSD 6-S4	Lambert Creek	1957	15,195	D & A
Venezuela	Shell	S-14	Zulia	9/10/55	15,198	D & A
Canada	Shell	LSD-6-28	Waterton	1960	15,205	D & A
Bolivia	Gulf	Yoay 1	Parapeti Block	1959	15,257	D & A
Canada	Texaco	LSD 6-S8	Simonette River	1958	15,283	D & A
Venezuela	Creole	Capitanejo 1	Barinas	5/16/59	15,288	D & A
Venezuela	Mene Grande	6-Y-6X	Zulia	7/27/59	15,341	Producer.
Venezuela	Mobil	Onado 1	Monagas	1960	15,375	D & A
Venezuela	Shell	CR-5	Zulia	11/ 5/59	15,491	Suspended.
Venezuela	Mene Grande	6-Y-4X	Zulia	12/24/58	15,531	Suspended.
Colombia	Richmond (Socal)	Buchado 1	Choro Pacific	1954	15,539	D & A
Spain	Ciepsa	Alda 1	Navarre	1956	15,552	Methane shows.
Colombia	Ecopetrol	Lisama 4	Mid Magd. Valley	1959	15,556	Oil show. Abd.
Venezuela	Shell	MGB-4X	Zulia	1960	15,565	Producer.
Venezuela	Mene Grande	75-Y-7	Zulia	1960	15,582	Producer.
Spain	Valdebro	Monesma 1	Huesca	1960	15,584	Gas shows.
Venezuela	Mene Grande	Pato 1	Anzoategui	6/ 6/56	15,795	Producer.
Venezuela	Mene Grande	PAG-2X	Santa Rosa	Drilling	15,800	—
Venezuela	Phillips	LPG 4-16	Zulia	1960	15,900	Producer.
Venezuela	Mene Grande	80-Z-1X	Zulia	7/11/58	15,994	Suspended.
Venezuela	King Mill	Socopo 2	Barinas	9/29/59	16,070	D & A
Venezuela	Richmond	36-E-2	Zulia	5/15/58	16,237	Producer.
Venezuela	Superior	A-139-1	Zulia	11/18/59	16,402	Suspended.
Venezuela	Richmond	36-E-3	Zulia	6/14/59	16,521	D & A
Venezuela	Creole	Alturitas 1	Zulia	9/15/50	17,039	Abandoned.
Venezuela	Creole	Alturitas 2	Zulia	11/28/53	17,173	Suspended.
Bahama	Gulf-Bahama California Oil	Cay Sal 1	Bahamas Banks	4/10/59	18,906	D & A

Meetings . . .

1961

Jan. 9-10 — **2-day seminar "Introduction to Plasma Dynamics"** by Dr. J. M. Burgers, Southern Methodist University, School of Engineering, Dallas, Texas.

Jan. 15-18 — **Pipe Line Contractors Association**, San Francisco, Calif.

Jan. 16-19 — **ISA Winter Instrument — Automation Conference and Exhibit**, Sheraton-Jefferson Hotel, St. Louis, Mo.

Jan. 19-20 — **National Industrial Conference Board**, general session, Waldorf-Astoria, New York City.

Jan. 20 — **Natural Gasoline Assn. of America**, Gulf Coast regional meeting, The Robert Driscoll Hotel, Corpus Christi, Texas.

Feb. 5-10 — **ASTM**, Committee D-2 meeting, Benjamin Franklin Hotel, Pa.

Feb. 16 — **National Industrial Conference Board**, meeting of board members, Waldorf-Astoria Hotel, New York City.

Feb. 24 — **Natural Gasoline Assn. of America**, South Louisiana regional meeting, Lafayette Petroleum Club, Lafayette, La.

Feb. 26-Mar. 2 — **Society of Petroleum Engineers of AIME**, annual meeting, Chase and Park Plaza Hotels, St. Louis, Mo.

Mar. 8-10 — **API Division of Production**, Southern District meeting, Captain Shreve and Washington-Youree Hotels, Shreveport, La.

Mar. 13-17 — **National Assn. of Corrosion Engineers**, annual meeting and corrosion show, Hotel Statler, Buffalo, N. Y.

Mar. 15-17 — **Natural Gasoline Assn. of America**, 40th annual convention, Baker Hotel, Dallas, Texas.

Mar. 20-24 — **12th Western Metal Congress and Exposition**, Pan-Pacific Auditorium, Los Angeles, Calif.

Mar. 22-24 — **API Division of Production**, Southwestern District meeting, Cole Hotel, Albuquerque, N. M.

Mar. 23 — **National Industrial Conference Board**, general session, Shamrock-Hilton Hotel, Houston, Texas.

Mar. 27-29 — **Midwest Gas Assn.**, annual meeting and convention, Sheraton-Fontenelle Hotel, Omaha, Neb.

Mar. 27-31 — **ISA**, 3rd Symposium on Temperature, Veterans Memorial Auditorium, Columbus, Ohio.

Apr. 5-7 — **API Division of Production**, Mid-Continent District meeting, Mayo Hotel, Tulsa, Okla.

Apr. 5-7 — **Kansas Oil Men's Assn.**, Management Institute, University of Kansas, Lawrence, Kan.

Apr. 9-11 — **14th Annual Midwestern meeting**, Society of Exploration Geophysicists, Oklahoma City.

Apr. 17-19 — **ISA**, 7th National Symposium, Shamrock-Hilton Hotel, Houston, Texas.

Apr. 20 — **National Industrial Conference Board**, meeting of board members, Waldorf-Astoria Hotel, New York City.

Apr. 24-27 — **AAPG-SEPM and Rocky Mountain section AAPG**, annual meeting, Denver-Hilton Hotel, Denver, Colo.

Apr. 26-28 — **API Division of Transportation**, pipeline conference, Chase-Park Plaza Hotel, St. Louis, Mo.

Apr. 28 — **Natural Gasoline Assn. of America**, Oklahoma regional meeting, Lake Murray Lodge, Ardmore, Okla.

Management Personals

Monroe E. Spaght was elected president of Shell Oil Company to succeed **H. S. M. Burns,** who retires at the end of this year. Spaght, who started his career with Shell as a research chemist, has been an executive vice president since 1953. Before that, he was president of Shell Development Company, Shell's research affiliate. Well known in scientific and educational fields, he is a director of Stanford Research Institute, American Petroleum Institute, Institute of International Education and a trustee of Stanford University.

M. E. Spaght

W. K. Whiteford

W. K. Whiteford, Gulf Oil Corporation's president since 1953, was elected chairman of the board, succeeding **Ralph O. Rhoades,** retired. Whiteford

E. D. Brockett

J. S. Stoffer

will continue as chief executive officer and Rhoades remains on the board. **E. D. Brockett,** formerly executive vice president, is president. Additionally, he will be vice chairman of the executive committee.

J. S. Stoffer is named financial coordinator, domestic production operations of Gulf. He succeeds **K. E. Rotegard** who was appointed manager of a newly established domestic services department. Both Stoffer and Rotegard will headquarter in Houston.

Edward L. Stauffacher, vice president of Cities Service Company, has been named chairman of the Petroleum Division of the New York Arthritis and Rheumatism Foundation.

Grady D. Harris Jr. and **A. T. F. Seale** were newly elected to the board of directors of Kerr-McGee Oil Industries, Inc. Harris is president of the Fidelity National Bank and Trust Company, Oklahoma City and Seale is vice president-operations of Kerr-McGee, a position he has held since 1954.

Re-elected directors are: **Breene M. Kerr, Robert S. Kerr, Robert S. Kerr Jr., T. M. Kerr, F. C. Love, D. A. McGee, J. B. Saunders,** and **James E. Webb,** all of Oklahoma City; **J. D. Blosser, Guy C. Kiddoo, Frederick W. Straus,** and **Dean Terrill,** all of Chicago; **Edwin L. Kennedy,** New York; and **J. H. Lollar Jr.,** Houston.

Sam W. Leonard, Cairo, Egypt is promoted to manager of personnel relations for Continental Oil Company's foreign operations. Formerly administrative manager of Sahara Petroleum Company, a subsidiary of Continental Oil Company, he will make his new headquarters in New York.

Arthur H. Bransky was appointed assistant general patent attorney and **Fred R. Ahlers, Michael Dufinecz,** and **Samuel Kahn** named senior patent attorneys in the patents and licensing department of the Standard Oil Company (Indiana) research and development department.

H. J. Fitzgeorge was appointed exploration advisor for Mobil Oil Company in New York.

Currently district exploration superintendent for Mobil's Midland district, Fitzgeorge will report to **Fred H. Moore,** vice president of the exploration and producing department. **Henry K. Holland, Jr.,** operating superintendent for the Denver Division, is named producing advisor for Mobil.

Philip S. Justice, manager of Sun Oil Company's Rocky Mountain division, was appointed to a newly-created post of special assistant to **Jno. G. Pew,** senior vice president in charge of production. He will undertake a series of comparative studies of certain of Sun Oil's undeveloped oil properties including economic analyses of policies and methods of acquisition, evaluation and development.

C. D. Owens Jr., was named director of personnel for Sinclair Oil Corporation and its subsidiaries. He formerly served as a member of Sinclair's industrial relations department in New York City.

W. O. Ham Jr. and **H. F. Nabors** were elected vice presidents of Continental Oil Company. Ham, continuing to headquarter in Houston, is general manager of the domestic exploration department. Nabors is production manager for the foreign exploration and production department in New York City.

M. C. Hoffman, a Chicago bank official specializing in the oil and public utilities fields, was elected president and a director of Alco Oil and Gas Corporation, Denver.

Thomas W. Moore is named vice president for supply and transportation, a new post, by Humble Oil & Refining Company. He was formerly a vice president and member of the board of management of the Esso Standard division in New York.

T. W. Moore

C. J. Reller

Charles J. Reller, treasurer of The Atlantic Refining Company, is appointed to the additional post of secretary of the firm. He succeeds **Richard Rollins** who retires.

H. T. Richardson was made director and vice president of Standard Oil Company of Texas. Formerly general manager-exploration, he succeeds **J. H. Todd** who transfers to California Oil Company, Western division, as vice president, exploration-production.

Robert Harcus, vice president and general manager of BJ Tools, Inc., has received his 15-year service pin.

Charles E. Nelson Jr., formerly executive vice president, is new president of Waukesha Motor Company succeeding **James E. DeLong,** retired. Other officers are: **J. G. Swain,** vice president; **L. W. Youker,** secretary and treasurer; **N. H. Willis,** vice president of engineering and **J. J. Kleinbrook,** assistant secretary-treasurer.

Loring S. Brock was appointed president of United States Steel Products Division. He formerly served as vice president of United States Steel. Brock succeeds **John Hauerwaas,** who retires.

Leslie M. Cassidy, former chairman of the board and president of Johns-Manville Corporation, and **Joseph H. King,** partner in Eastman Dillon, Union Securities & Co., are named to the board of directors of Olin Oil & Gas Corporation.

Dr. Donald W. Collier has been named vice president — research for Borg-Warner Corporation.

Dr. Collier formerly served as president of the Thomas A. Edison Research Laboratory Division of McGraw-Edison Company.

J. Ronald Getty was named president and general manager of Veedol International, newly-formed to direct the expanding operations of Tidewater Oil Company's European manufacturing and marketing subsidiaries other than Dansk Veedol, the Danish-based

subsidiary which Getty will serve in an advisory capacity. He will also direct Tidewater's export operations in Europe, Africa and the Middle East. Central offices for Veedol International are in Switzerland.

Getty has been Tidewater's marketing manager and a member of the company's board of directors since 1957. He has served as managing director of Veedol GmbH, West German subsidiary.

▸ **Marlin P. Nelson,** senior chemical engineer in Advanced Management and Methods Division, Sun Oil Company, was named assistant director of that division. He works directly with **Paul D. Barton** and **John F. Harron.**

CORRECTION:

In the article *"Petroleum Powers Western Europe's Economic Boom"* which appeared on page E-1 of the November 1960 issue, this correction should be made: In the right-hand column of page E-2, second paragraph, the estimated gas reserves of the giant gas field R'Mel in the French Sahara are given as 35 billion cubic feet. **The estimated reserves should read 35 trillion cubic fe**t.

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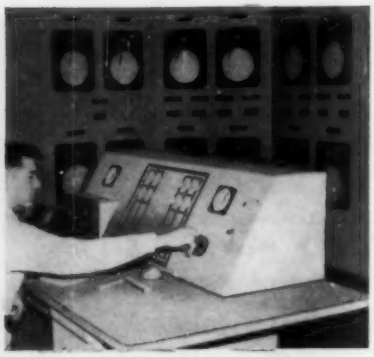

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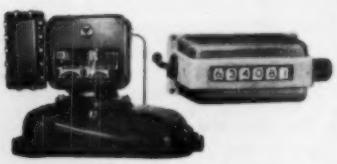

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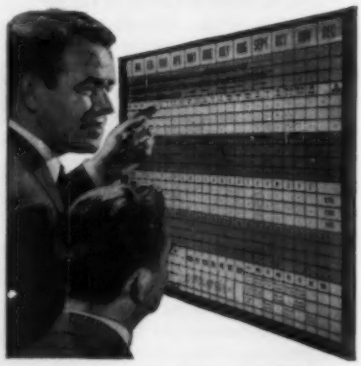

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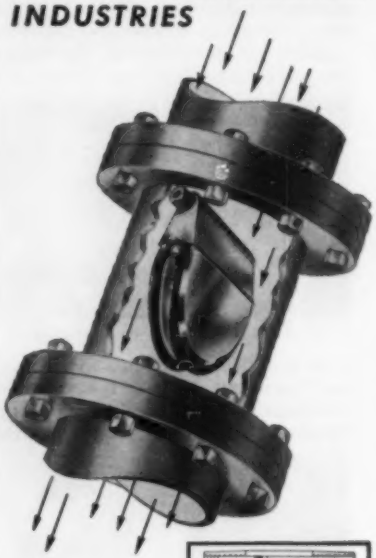

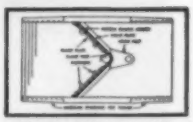

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Books To Read . . .

"Classics in Management," *edited by Harwood F. Merrill. Published by American Management Association, Inc., 1515 Broadway, New York 36, New York. 446 pages. Price, $9/ AMA members: $6.*

As the foreword says the roots of the emerging profession of management go deep, just as those of older professions. The AMA publication staff decided that since management is a profession, the professional manager should be familiar with the "classic" body of management literature. This is an attempt to collect books and articles of the past that show pioneering concepts of management practice.

Earliest is an "Address to the Superintendents of Manufactories" by Robert Owen taken from a book "A New View of Society" published in 1813.

These selections express the principles that have made management a profession and have molded business and industry in the Western World. It's an absorbing picture and one you may not have been aware of. These classics are worth your study.

"The Craft of Technical Writing," *by Daniel Marder. Published by The MacMillan Company, 60 Fifth Avenue, New York 11, New York. 400 pages. Price, $5.00.*

You are in a technological field in which progress is synonymous with the exchange of information . . . and the written record is enduring proof of what you or your company have uncovered and offered for the use of the industry. If you have trouble writing . . . whether it be the internal company report or an article for a technical publication . . . and you don't want your supervisor or others to think you are trying to hide inadequacies, that your logic is weak, or that you are trying to cover up lack of creativity with a curtain of learning . . . then certainly you will want to pick up Daniel Marder's pointers on mastering the craft of technical writing.

He shows you how to create an entity through the principles of rhetoric . . . unity, coherence, and emphasis; discusses techniques for solving major organization problems confronting the technical writer; and shows how to apply these techniques to the whole structure. Finally, he presents challenging applications, representing actual writing situations that you will encounter throughout your career.

"The Art of Problem Solving," *by Edward Hodnett. Published by Harper & Brothers, 49 East 33rd Street, New York 16, New York. 202 pages. Price, $3.50.*

This book deals with problem solving as both science and art, to be applied to the endless variety of situations confronted in everyone's personal, business, or professional life. It is written by a distinguished educator, a man who is wise, witty, and widely informed.

Professor Hodnett points out in his opening chapter, "Problem solving is everybody's problem. Whether you are a housewife, a druggist, a secretary, a student, a filling-station operator, a business executive, or the man who lives in the White House, you have to solve problems. Fortunately, human beings like to solve problems. Otherwise how can you explain people who play chess, climb mountains, and offer to open folding bridge tables?"

The thesis of the book is that common procedures, skills that can be developed like any others, underlie all problem solving. It is organized in four parts: Diagnosis, Techniques, Scientific Approach, and Art. Under these the author discusses how to ask questions, how to get facts straight, how to find alternatives, how to estimate consequences, how to be logical, and how to find imaginative solutions. Each step is illustrated with a clear example.

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This is an excellent opportunity for rewarding work and personal development. Stock purchase, pension and other employee benefit plans are excellent. *Age limit 45. Send your complete, detailed resume, including salary requirements.* Box 6810. The Petroleum Engineer, P.O. Box 1589, Dallas 21, Texas.

OPPORTUNITY WANTED

to utilize extensive background in purchasing, warehousing, material control, administration and sales. Best references. Box 2103, The Petroleum Engineer, P. O. Box 1589, Dallas 21, Texas.

EUROPEAN REPRESENTATION

French sales company highest references with excellent contacts among buyers in production, transportation, refining and marketing divisions of the petroleum industry throughout Europe wants exclusive representation of a manufacturer wishing to sell equipment or products to this industry.

Reply to Box 228

THE PETROLEUM ENGINEER
P. O. Box 1589 Dallas 21, Texas

DRILLING-PRODUCTION MANAGEMENT EXPERIENCE

available in Permian Basin area. Experience includes work in secondary recovery and management of own drilling contracting firm. Box 1837, The Petroleum Engineer, P. O. Box 1589, Dallas 21, Texas.

PETROLEUM ENGINEER AVAILABLE

Registered petroleum engineer seeks employment in production department of independent operation. Experienced in geology. Will relocate. Box 1843, The Petroleum Engineer, P. O. Box 1589, Dallas 21, Texas.

SALES MANAGEMENT OPPORTUNITY WANTED

by successful sales manager with record of supervision of $7.5 million annual sales operation. Administrative experience includes warehousing, billing, credit collection, sales analyses and forecasts. Box 1800, The Petroleum Engineer, P. O. Box 1589, Dallas 21, Texas.

EMPLOYMENT WANTED

Specialist in asphalt technology available for permanent assignment or consulting work. Extensive overseas experience in refinery operations, design of processing units and lube manufacture. Holds 11 U. S. patents. Box 1926, The Petroleum Engineer, Box 1589, Dallas 21, Texas.

For Constant, Uninterrupted POWER FLOW in the OIL FIELDS

You'll Never Go Wrong with FIELDMASTER BALL BEARING MOTORS

Here's Why . . .

They are specifically designed to overcome the unusual conditions of Oil Field requirements, and there is a type and H.P. built to fit your exact needs. Unexcelled since they are . . .

- DRIP PROOF
- VERMIN PROOF
- MOISTURE PROOF
- CORROSION RESISTANT
- FORCED AIR COOLED
- HAVE SEALED TERMINAL PORT

SEMI-ENCLOSED — normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings in semi-enclosed protected housing, 40 degree C rise. Built for continuous duty. High Torque, low starting current. Extra insulating coating throughout.

TOTALLY ENCLOSED — Fan cooled, normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings, totally enclosed FAN cooled 55 degrees C rise, for continuous duty. High Torque — low starting current. Extra insulating coating throughout.

Write for fully descriptive literature

BETHLEHEM STEEL CO. Supply Division **Tulsa, Oklahoma**

Manufactured by Valley Electric Corporation, St. Louis 8, Mo.

Laugh with Barney

A small soiled youngster accompanied by his even smaller brother stopped an elderly lady as she was passing their house.

"For a nickel I'll have by brother imitate a hen for you," said the boy.

"And how does he do that, my little man? Cackle?" asked the lady.

"Oh, no, m'am," said the little boy indignantly. "None of them cheap imitations for us . . . I'll have him eat a worm."

* * *

Golf is the game that turned the cows out of the pasture and let the bull in.

* * *

Two Hollywood children were talking as they were walking home from school one day.

"I've got two little brothers and one little sister," boasted one. "How many do you have?"

"I don't have any brothers or sisters," answered the second one, "but I have three papas by my first mama and four mamas by my last papa!"

* * *

An executive who is a great believer in efficiency hung up a sign in his office one day last week. It read: "Do It Now."

Within 24 hours the cashier bolted with the contents of the safe, his stenographer eloped with his eldest son, the office boy threw the ink bottle into the electric fan, and the whole office force took the afternoon off.

* * *

An admirer came up to a senatorial candidate after his speech and said:

"Congratulations. That was a fine speech. I like the straightforward way you dodged those issues."

* * *

An old Indian visited the big city for the first time in his life. He entered a building and watched a little old lady step into a small room.

The doors closed behind her. Lights flashed, and a dial above the door moved from one up to ten and back down again. A bell tinkled. The doors came open, and a beautiful young girl stepped out of the elevator.

Blinking in amazement, the Indian grunted, "Me should have bring um squaw."

* * *

A somewhat haughty government inspector approached a farmer and demanded to see his livestock.

"My card, sir. It entitles me to inspect your farm."

A little later the farmer heard screams from his alfalfa patch where the inspector was being chased by a bull. Leaning over the gate as the inspector drew near, the farmer cried, "Show him your card, mister, show him your card!"

* * *

Girl at perfume counter: "Is there one that means 'some other time?' "

Two ministers, given to arguing about their respective faiths, were in a very heated discussion. "That's all right," said one, calmly. "We'll just agree to disagree. After all, we're both doing the Lord's work—you in your way and I in His."

* * *

Life's an everlasting struggle to keep money coming in and teeth and hair from coming out.

He was in a hurry, so the man decided to take a shortcut that took him the wrong way down a one-way street. He didn't make it. A siren sounded, and a patrolman waved him to the curb.

"Just where do you think you're going?" sneered the patrolman.

"Don't know," replied the driver, "but wherever it is, I'm late. Everyone else is coming back already."

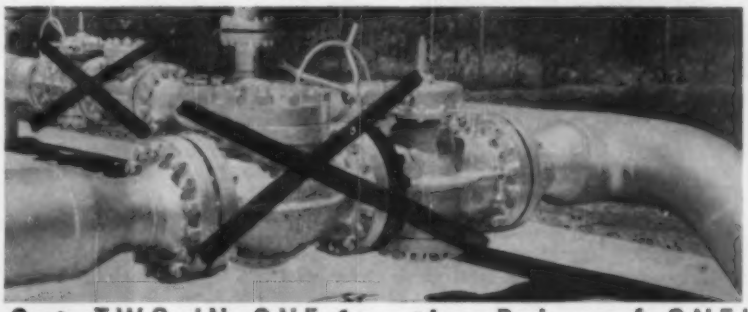
* * *

The district attorney was questioning a Kentucky colonel in court. Unable to shake his testimony he tried sarcasm. "They call you colonel," he sneered. "In what regiment are you a colonel?"

"Well, it's like this," drawled the colonel. "The 'colonel' in front of my name is like the "honorable' in front of yours. It doesn't mean a thing."

WHY BUY 2 ? . . . WHEN 1 WILL DO!

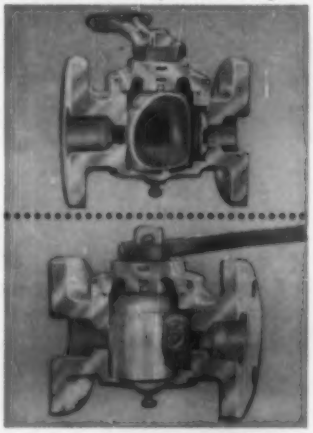
ONE FRANK WHEATLEY PLUGAROO!



Get TWO-IN-ONE for the Price of ONE!

- The Plugaroo is a combination non-lubricated plug and check valve!
- The plugaroo completely eliminates the need of one valve!
- Save 50% by buying the PLUGAROO!
- Over 20,000 now in use!
- Available in sizes 2" to 10"; full or regular opening!
- Example: Factory shipment price for 2" screwed ends — only $10.39.
- Send for descriptive literature or see pages 5634 and 5635 in Composite Catalog.

Why buy two valves, when one non-lubricated PLUGAROO combination plug and check valve . . . will do the job better and cheaper? As a check, the clapper-hinged on a 20° angle . . . seals under its own weight. As a plug, a quarter turn gives a positive seal without galling or scoring plug, clapper, or valve body. Available with Teflon or Synthetic Rubber seals in steel, semi-steel, or aluminum bronze from Series 15 to 90. Full opening sizes 2" to 10" in all API, ASA dimensions and end connections. Write for further details.



Cut-away illustrates **PLUGAROO** with plug "closed" (top) and as check valve "open" (bottom).

SINCE 1916

FRANK WHEATLEY PUMPS & VALVES TULSA, OKLAHOMA

ALSO NEW . . .

the **SLAM-MINIMIZER CHECK VALVE** for high pressure gas lines . . . and the new **SPHERE-CLEAR CHECK VALVE** for lines using ball-markers for interface and batch change.

SEE OUR CATALOG IN COMPOSITE CATALOG

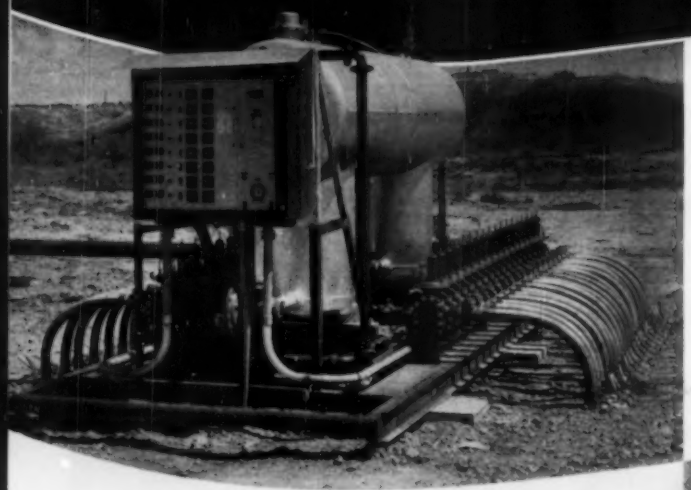
P. O. BOX 1948 • LU 4-5175
TULSA, OKLAHOMA

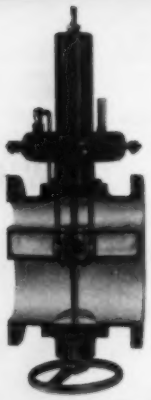
YOUR SUPPLY STORE SHOULD HAVE THEM!

NATIONAL®

Packaged Well Test Unit

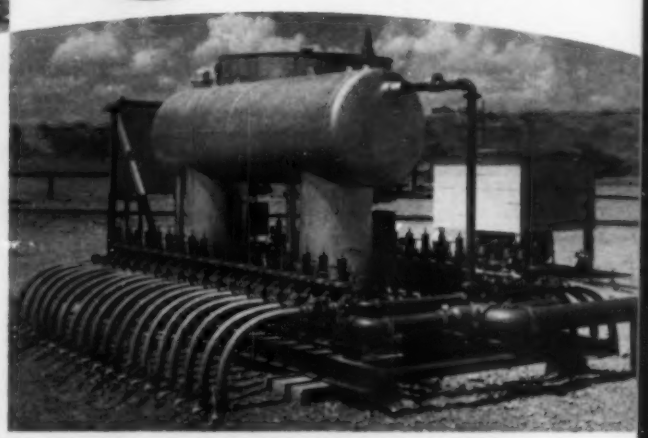
"Tests Better Automatically"





National MANI-FLO® Valves make this compact unit possible. MANI-FLO Valves require no lubrication and no expensive well-headers. When bolted together, MANI-FLOS are their own well-header and test line . . . self-contained . . . — Unique!

PATENT APPLIED FOR



AUTOMATICALLY DIVERTS FLUID STREAMS FROM WELLS, THEN SEPARATES, MEASURES, AND RECORDS QUANTITIES

- Automatically programs each of **36** wells in sequence for scheduled test.
- Separates oil, gas, and water.
- Measures the oil and water in the National Type B Liqua-Meters located in the legs of the National O-G-W MONOTUBE® SEPARATOR.
- Accumulates the volume of each product on the reset counters on the control panel.
- Strip Chart Recorder records production in relation to time.
- Separated products commingled and returned to the production line after test.
- Electric control panel actuates the pneumatic operated MANI-FLO valves to place well on test or production.
- Pictured unit does not measure or record gas production, but facility may be added at nominal cost on the same skid.
- Any power failure diverts all valves to production.
- Wells may be shut in manually with handwheel on bottom of MANI-FLO valve.

CONTROL PANEL

Weatherproofed and rain shielded. Clear plastic window allows complete visibility of all counters, well selector switches, and Strip Chart Recorder. Light indicates well on test.

STRIP CHART Recorder indicates:

Best production hours.
If well is flowing and/or surging.
Proper operation of pumping well.
Accurate well performance.

A Plus Value With All National Products . . . Engineers and field crews living in your area with stocked warehouses, complete units or parts ready to size, install and service National Well Test Units!

It's a National®

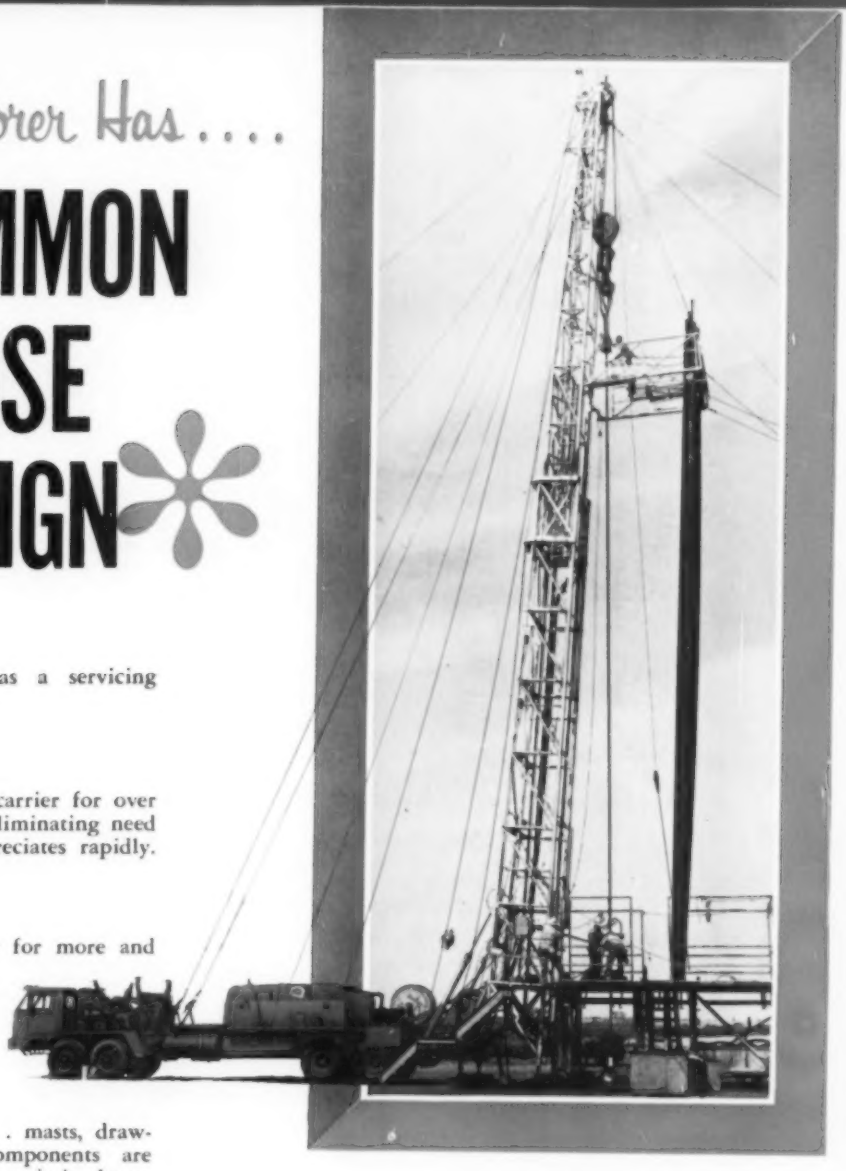
NATIONAL TANK COMPANY

DRAWER 1710

TULSA, OKLAHOMA

Franks Explorer Has....

COMMON SENSE DESIGN*



***CSD...**

Primarily designed as a servicing and workover rig.

***CSD...**

Mounted on rugged carrier for over the road travel . . . eliminating need for truck which depreciates rapidly.

***CSD...**

Industrial horsepower for more and faster work.

***CSD...**

Greater flexibility . . . masts, drawworks and other components are interchangeable. Your unit is always up-to-date.

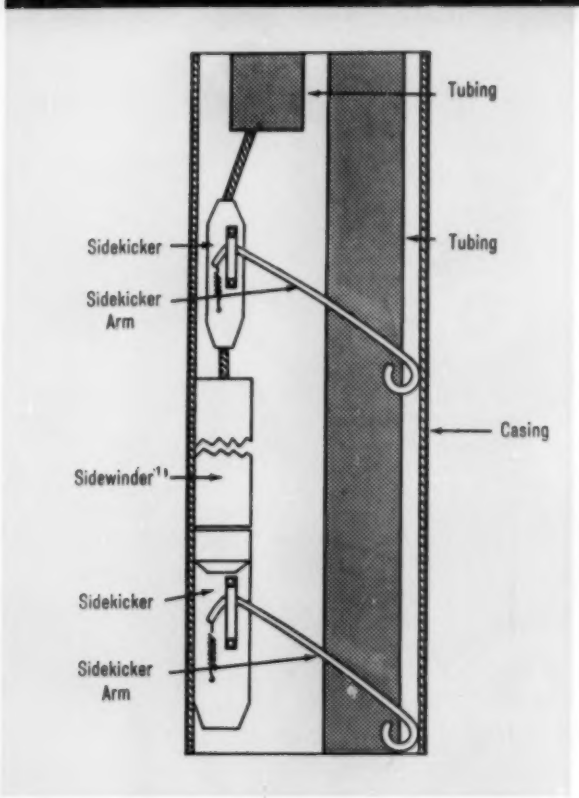
More Franks Explorers are sold than any other competing make — pretty good proof that the Franks Explorer **packs more punch!** Ask your Franks Representative for the facts.

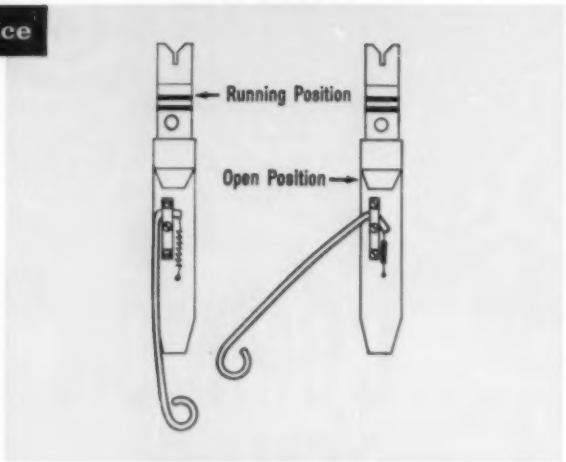
WELL SERVICING AND DRILLING UNITS
FRANKS
PAMPA, TEXAS
CABOT

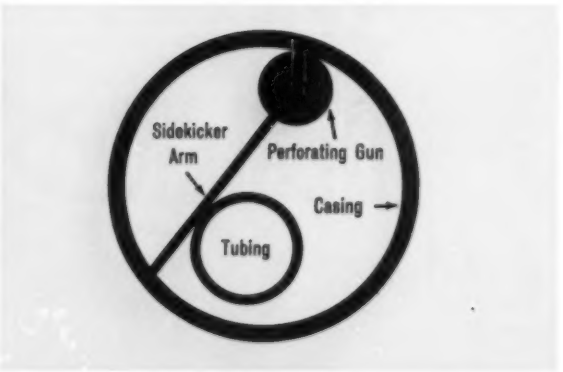
CABOT CORPORATION
MACHINERY DIVISION

Worth more when you BUY 'EM . . . Worth more when you TRADE 'EM

Revolutionary New Completion Service







Sidekicker Solves Dual PWC* Problems

*** Permanent Well Completions**

Welex engineers have answered the problem of perforating an upper zone with no risk to the adjacent tubing string in dual permanent well completions. The new development — another first by Welex — offers these advantages:

- Service can be performed through 2" tubing and standard seating nipples.
- The Sidekicker, a mechanical orienting decentralizer developed by Welex, forces the Sidewinder[1] perforating gun against the side of the casing, assuring maximum penetration.
- The Sidekicker positions jet gun so that the charges will fire outward through the casing — never in the direction of the adjacent tubing string.
- Sidewinder[1] retrievable carrier absorbs the shock of detonation, protecting adjacent tubing string from damage.
- Absolutely no debris is left in the hole. All debris is retained in the carrier and returned to the surface.

Welex, the company that originated jet perforating proudly adds this new service to the other "firsts" that it has introduced to the oil industry.

In Permanent Well Completions, as well as in other types of completions, Welex has a complete set of tools for every job. Next time and every time let Welex's completion services work for you.

WELEX, INC.

ORIGINATORS OF Welex JET PERFORATING

General Offices: 1400 East Berry, Fort Worth, Texas
In Canada: Welex of Canada, Ltd.

[1]Trademark of Jet Research Center, Inc.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Of Things To Come . . . In Oil

BETTER DAYS FOR OIL IN 1961 are being forecast by more and more industry observers. The Independent Petroleum Association of America sees an increase in domestic and export demand of 2.3% over its 1960 estimates, with total 1961 demand averaging 10,098,000 bbl per day. E. E. Wall, California Oil Company president, expects this total demand figure to reach more than 15,000,000 bbl daily by 1975. He also sees immediate step up in drilling as inventories correct themselves. And Warren L. Baker, AAODC executive vice president, notes that "an increasing number of signs provide grounds for hoping the downward trend in U. S. drilling activity may have reached bottom."

SMALL HYDRAULIC WORKOVER UNITS will help bring down costs of well servicing and workover jobs in wells with small diameter tubing, especially in offshore locations. Designed for working on wells under pressure without having to kill the wells with mud, two such all-hydraulic rigs have recently been introduced by Brown Oil Tools, Inc., Houston, and Otis Engineering Corporation, Dallas.

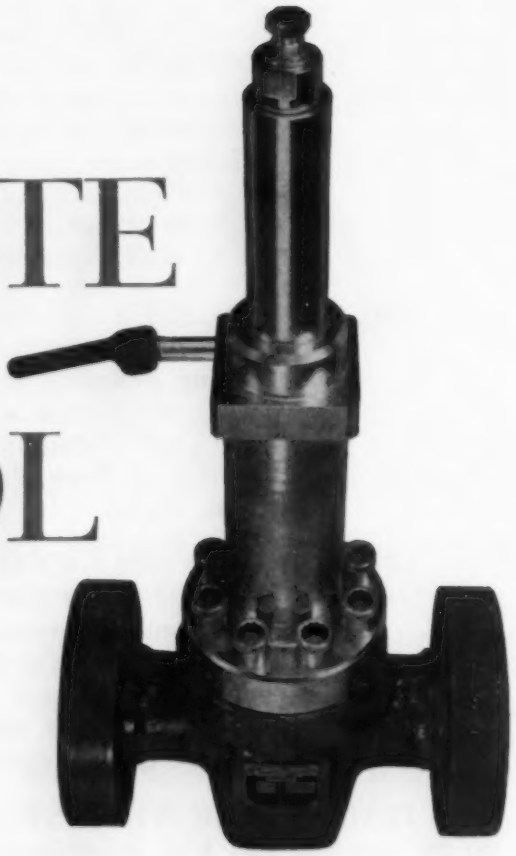
UNDERWATER WELL COMPLETIONS WILL INCREASE following the lead of the first such installation made by Peruvian Pacific Petroleum Company under 130 ft of water off the coast of northern Peru. Oil flows from the well to a tank farm ashore through a string of 3-in. aluminum pipe anchored to the ocean bottom. A ½-in. aluminum line transmits hydraulic power to actuate the Christmas tree valves.

ITALY HAS HIGH HOPES FOR IRAN following a 3500 bbl per day strike by ENI in offshore Persian Gulf waters. Enrico Mattei, in an exclusive interview with The Petroleum Engineer in Rome, said that ENI is building a pipeline and expects to increase its Iranian production to an average of 6000 bbl per day in 1961, 16,000 bbl in 1962, and 50,000 bbl per day by 1963.

OFFSHORE DRILLING IN PACIFIC NORTHWEST appears to be a certainty in the near future as reflected by increased applications for seismic permits, George Abbott, assistant U. S. Secretary of the Interior commented recently.

The Cameron Automatic Safety Valve on a Christmas tree wing protects unattended lease equipment 24 hours a day – effectively safeguarding Products, Property and Profits • High Well Pressure is kept under constant positive control to protect – and guard against malfunction – all equipment downstream from the tree • When pressure drops or rises beyond preselected points the Cameron Automatic Safety Valve closes with a firm regulated action • Control pressure may be in the valve body itself or from a remote source • A manual control provides instant overriding action for conventional operation or resetting

COMPLETE WELL CONTROL



CAMERON AUTOMATIC SAFETY VALVE

The Cameron Automatic Safety Valve assures unequaled safety, performance and economy.

1. Simple, rugged design – only three main moving parts.
2. Accurate performance over extended periods without readjustment.
3. High and low trip points are independently adjustable.
4. Manual operation permits simple, fast choke changing.
5. Proven by almost three years of punishing field tests.

A Cameron Representative will show you how this valve will give you more protection *and* save you money.

Cameron

CAMERON IRON WORKS, INC.

P. O. Box 1212 Houston, Texas

Plants and Sales Offices throughout the world

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another
TRETOLITE SERVICE
report

SOLVO®
PARAFFIN REMOVER

. . . prevents paraffin accumulation

ELIMINATES COSTLY WELL-PULLING, STEAMING, CHEMICAL CLEANING

In few places is the wisdom of the "ounce of prevention" more evident than in treatment against paraffin accumulation.

Corrective measures such as well-pulling, steaming, and chemical clean-out are costly, and they are only temporary at best. They provide no permanent corrective answer to the problem and paraffin accumulation will soon be back, requiring another treatment.

SOLVO® Paraffin Remover corrects by preventing

In many applications Solvo will remove paraffin deposits, but it is most effective and economical when used in a planned program of *preventive treatment*.

What SOLVO is

Solvo Paraffin Removers are organic liquids, dispersible in both oil and water. They contain no carbon bisulfide or carbon tetrachloride and are essentially chloride-free. This is important to the refiner. Solvo Paraffin Removers are safe to use because they have high flash points, low vapor pressures.

Ask your Tretolite field service engineer (the "Man in the Red Car") for more facts and figures on Solvo-preventive maintenance in *your* wells.

TPR-60-2

*Registered trademark of Petrolite Corporation

PETROLITE
CORPORATION

TRETOLITE COMPANY
DIVISIONS
369 Marshall Avenue, Saint Louis 19, Missouri
200 South Puente Street, Brea, California

SUBSIDIARY AND AFFILIATED COMPANIES
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"A great step forward with your Planetary Gears, Big Bearings and Cylindrical Crossheads."

— J. K. Butler

WHELAND PLANETARY
HP-16000 PUMP
Duplex Power Slush Pump
7¾" x 16", 600 H.P. at 65 RPM

OIL PRODUCTION MAINTENANCE, INC.
7440 CHOCOLATE BAYOU ROAD -- P. O. BOX 14291
HOUSTON 21, TEXAS
August 31, 1960

Mr. Gordon P. Street, President
The Wheland Company
Chattanooga, Tennessee

Dear Mr. Street:

Our Wheland Planetary Pump is giving us increased penetration and good savings on bits. We know from more than 18 months of constant operation on 10,000 Ft. wells that our savings are substantial.

We have kept an accurate record on operating costs and all maintenance costs and are especially impressed by the low cost of fluid end expendables. The HP-16000 Pump has constantly operated near its rated capacity on more than 200,000 feet of hole in the Texas Gulf Coast Area.

We are now operating Wheland HP-18000, HP-14000, and HP-16000 Pumps and are glad to recommend them. Your new HP-16000 Pump design is a great step forward with your planetary gears, big bearings and cylindrical crossheads.

Yours very truly,

OIL PRODUCTION MAINTENANCE, INC.

J. K. Butler

J. K. Butler, President

Wheland HP-16000 Planetary Pump owned by Oil Production Maintenance, Inc., on location in the Gulf Coast area.

WHELAND

ROTARY DRILLING MACHINERY

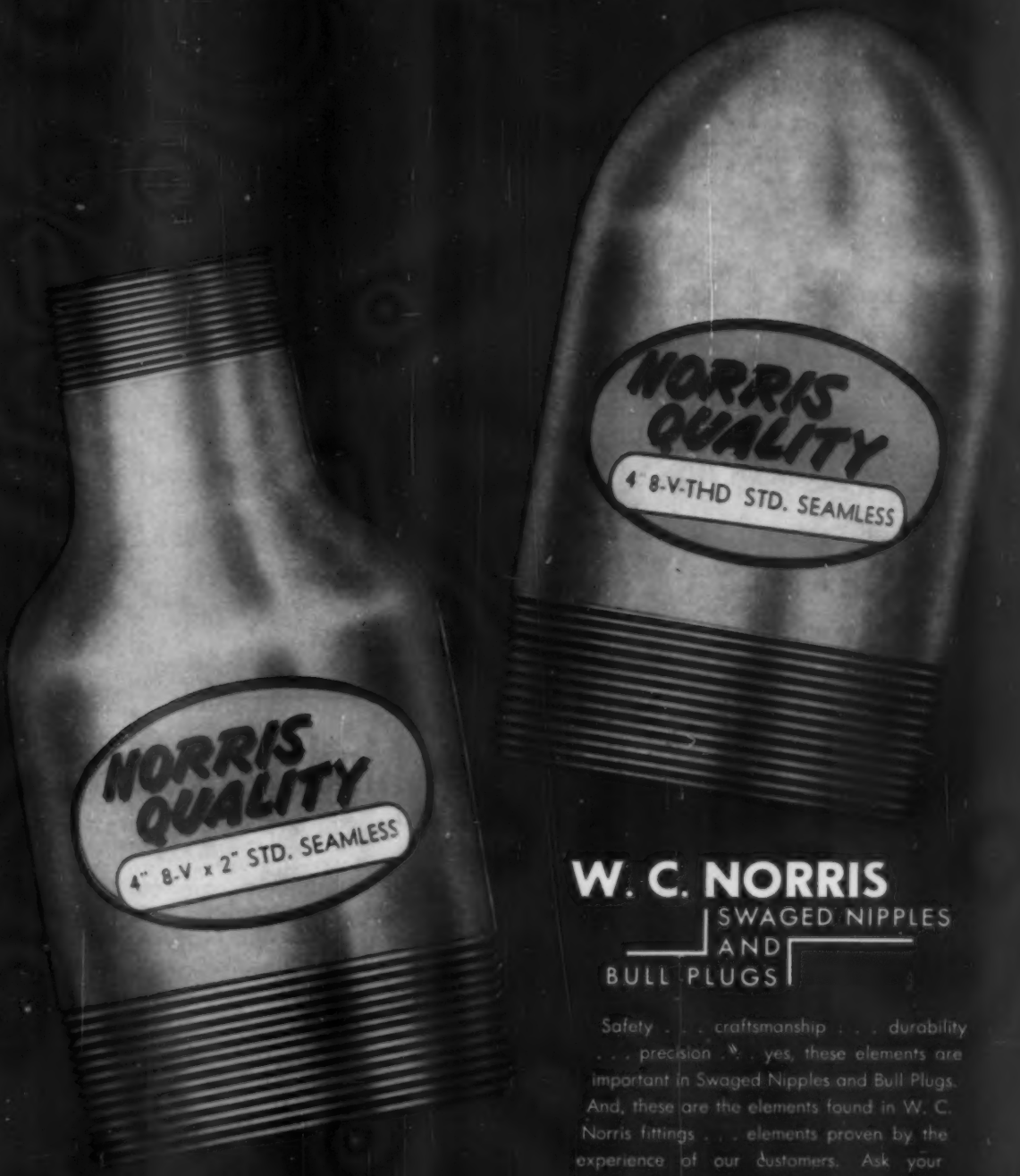
THE WHELAND COMPANY
CHATTANOOGA, TENNESSEE, U.S.A.

DRAW WORKS • SLUSH PUMPS • ROTARIES
CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

DOMESTIC DISTRIBUTORS: INDUSTRIAL SUPPLY COMPANY, INC.—Main Office: Wichita Falls, Texas • HOUSTON OIL FIELD MATERIAL COMPANY, INC.—Main Office: Houston, Texas.

EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

PROVEN BY EXPERIENCE



W. C. NORRIS
SWAGED NIPPLES AND BULL PLUGS

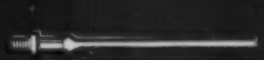
Safety . . . craftsmanship . . . durability . . . precision . . . yes, these elements are important in Swaged Nipples and Bull Plugs. And, these are the elements found in W. C. Norris fittings . . . elements proven by the experience of our customers. Ask your Norris man for complete information.

NORRIS QUALITY
TUBULAR PRODUCTS

Buy From Your NORRIS Distributor

W. C. NORRIS, MANUFACTURER
DIVISION OF DOVER CORPORATION
TULSA, OKLAHOMA • P. O. BOX 1739

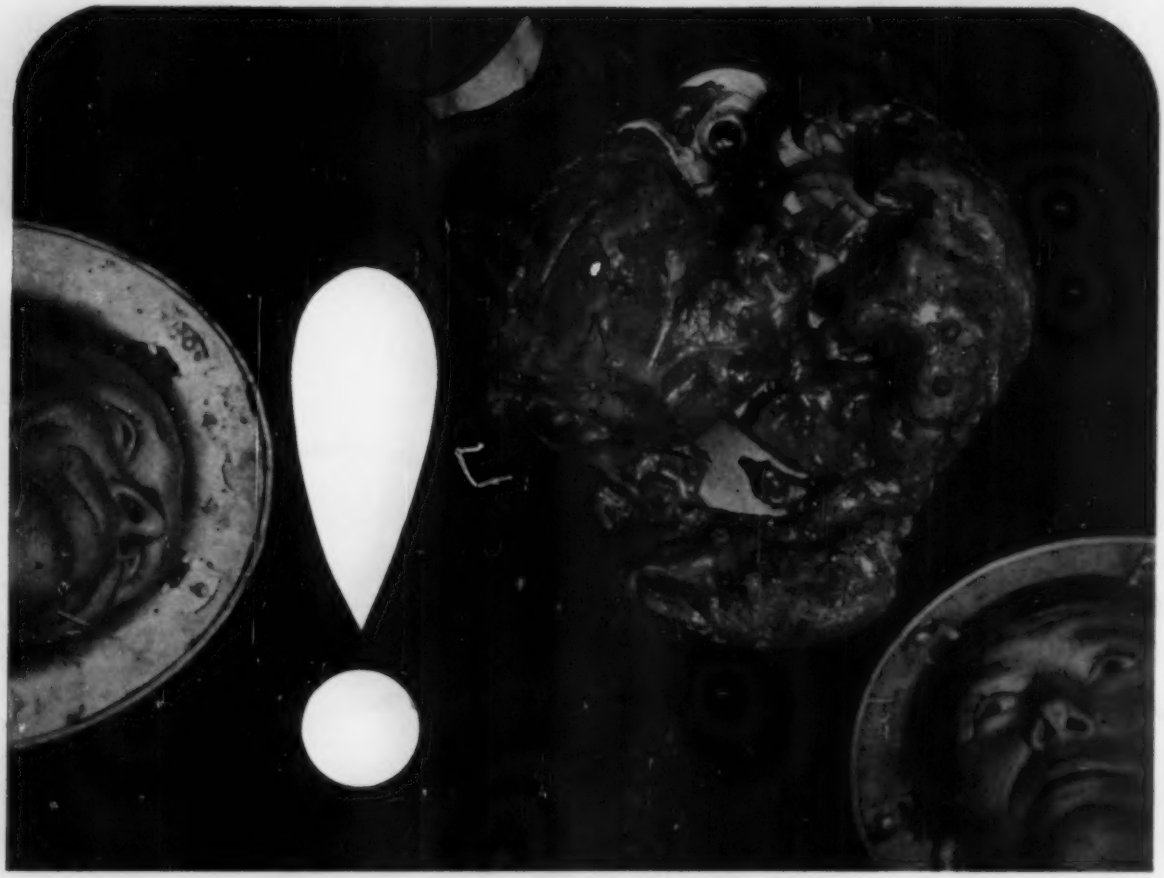
BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada.


SUCKER RODS

• OTHER NORRIS CHAMPIONS

VALVES 150 PSI

WELL HEAD EQUIPMENT



Next time try a Baroid Mud Program

Baroid has reduced the element of chance and increased the element of success in *your* drilling mud program by integrating *every* step of production, distribution, and engineering application into a single chain of service. Oil companies and contractors who use this sensible plan know that such streamlining produces marketing efficiency.

When a single set of high standards are applied to every step, the end result is lower drilling costs and better completions. Baroid's mining, manufacturing, quality control, new-product research, warehousing, delivery and engineered application are maintained at the exacting level you expect.

Only through such coordination can uniform standards be extended from a local or regional level to one of national or international scope. In product quality, dependable delivery and engineering skill, you get Baroid excellence whether your well is near Coalinga or Casper; Corpus Christi or Crowley; Caracas or Calgary. *You save drilling dollars* with a Baroid Mud Program!

BAROID

BAROID DIVISION NATIONAL LEAD COMPANY

MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

6048

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Trinity
LITE-WATE

A Complete Low Density Cement that is

HIGHLY IMPERMEABLE

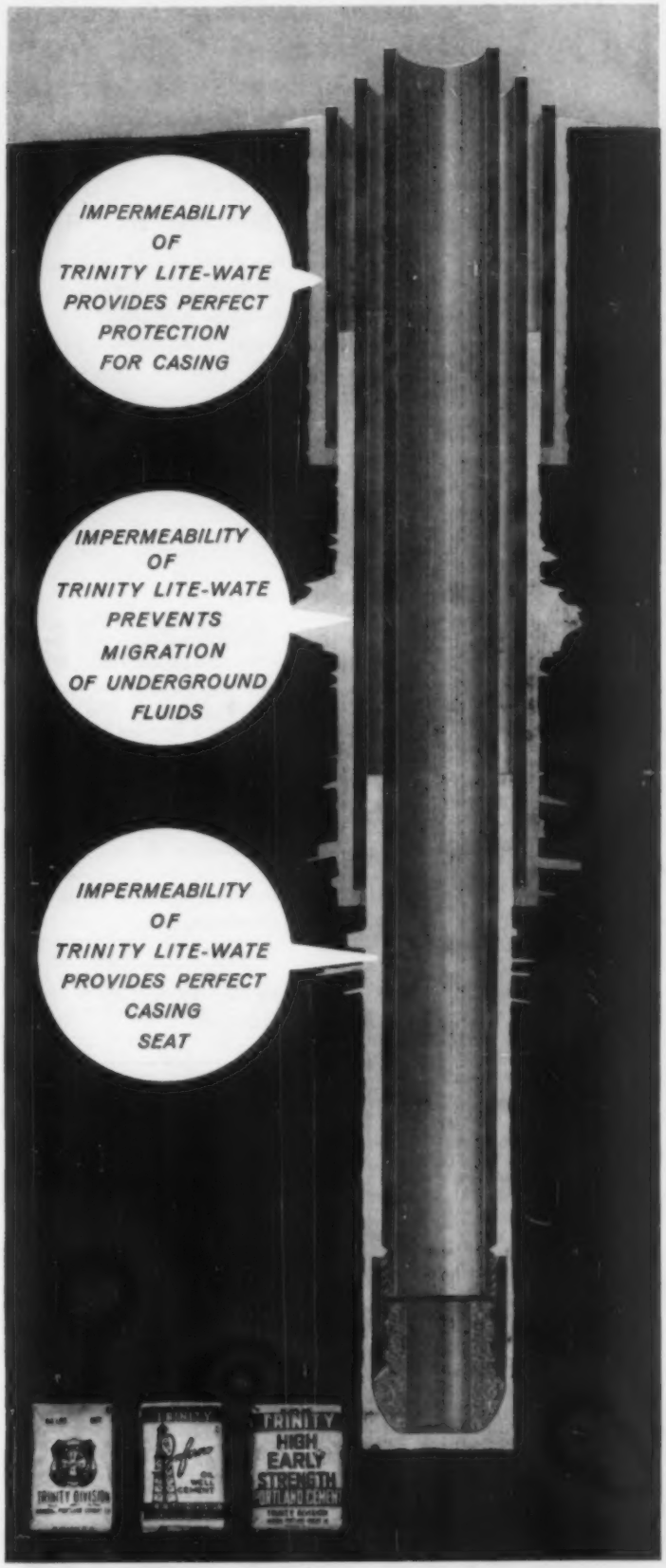
Trinity Lite-Wate fulfills all important functions when placed in an oil or gas well.

PERMEABILITY TEST DATA

All slurries were prepared according to procedures of API RP IOB and cured at 140°F and atmospheric pressure for 72 hours.

Percent Mixing Water	Slurry Wt. Pounds Per Gallon	Permeability Millidarcys*
65	13.66	0.001
75	13.18	0.001
85	12.77	0.001
95	12.44	0.001
105	12.14	0.002
115	11.89	0.003

*A darcy is that measurement of permeability that will permit a liquid having a viscosity of one centipoise to flow at the rate of one milliliter per second through a specimen one centimeter in length and having a cross section of one square centimeter under a pressure difference of one atmosphere. A millidarcy is 0.001 darcy. The permeability of Trinity Lite-Wate cement is expressed in millidarcys.


IMPERMEABILITY OF TRINITY LITE-WATE PROVIDES PERFECT PROTECTION FOR CASING
IMPERMEABILITY OF TRINITY LITE-WATE PREVENTS MIGRATION OF UNDERGROUND FLUIDS
IMPERMEABILITY OF TRINITY LITE-WATE PROVIDES PERFECT CASING SEAT
TRINITY
HIGH EARLY STRENGTH PORTLAND CEMENT

TRINITY

PORTLAND CEMENT DIVISION
GENERAL PORTLAND CEMENT COMPANY

DALLAS·FT.WORTH·HOUSTON

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

A superior thru-tubing jet perforator featuring:

ENCLOSED FIRING SYSTEM

MINIMUM DEBRIS

DEEP, CARROT-FREE PENETRATION

HIGH WELL FLOW INDEX

ALL NEW McCULLOUGH *mac-jet*

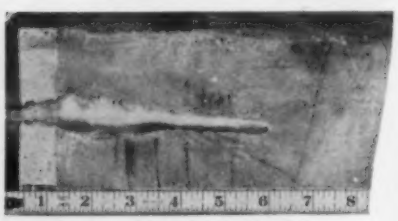
The McCullough Mac-Jet is an all-new development in expendable jet perforating – designed to provide maximum perforating efficiency – to obtain highest production from thru-tubing and slim hole completions.

- Enclosed Firing System – Each Mac-Jet unit is self-contained, including jet charge and integrated firing system, enclosed in a frangible, high strength case. This design eliminates the use of exposed primacord. Units are securely locked together and may be fired from bottom up or from top down.
- Minimum Debris – Entire Mac-Jet Perforator breaks up into small bits when fired. Mac-Jet units, spacers and bottom firing assembly are all disintegrating to assure complete break-up.
- Superior Perforation Characteristics – "big gun" performance – penetration equal to or better than that of many larger jet casing guns. Carrot-free perforations, large deep holes, high well flow index.
- Size, Shot Density, Length – 1 11/16" OD and 2 1/16" OD Standard shot density is four per foot, 90° phasing.

Disintegrating spacers are supplied to provide fewer shots per foot when required. Any number of Mac-Jet units may be run in any length desired.

SPECIFICATIONS:

	1 11/16" OD	2 1/16" OD
Pressure, Temperature Rating	15,000 psi. @ 300°	13,500 psi. @ 300°
Maximum Temperature	350°	350°
Total Charge Weight	12 grams	20 grams
Av Penetration (Berea Sandstone)	5.69"	7.45"
Av Entrance Hole	13/32"	3/16"
Av Well Flow Index	1.1+	1.44
Fill-up – 1' Gun, 5 1/2" Casing	1"	–
Fill-up – 1' Gun, 7" Casing	1/2"	1"



Standard Berea Sandstone target perforated by 1 11/16" OD Mac-Jet. Average penetration, 5.69"; average entrance hole size, 13/32; average well flow index, 1.1+

DISINTEGRATING SPACER – Available in various lengths to provide fewer than four shots per foot. Disintegrates into small bits when perforator is fired.

McCullough *TOOL COMPANY*

LOS ANGELES • HOUSTON • EDMONTON • *CABLE ADDRESS: MACTOOL*

AVOID DELAY!

see CONTINENTAL-EMSCO first for any oil field rubber product

Your time is too valuable to waste in searching for the right oil field rubber products. That's why your Continental store normally keeps the industry's broadest inventory, from stuffing box rings to rotary hose. And for unusual-application items, convenient field warehouses *eliminate needless waiting* for shipment from distant points.

Made by New York Belting and Packing Company, these products provide the sort of quality that pays off in better performance and longer life. Take Green Triangle Super V-Belts, for example: Their load capacity equals any on the market. Cords are built in under tension with error-proof electronic precision, assuring maximum shock resistance and better load distribution. A unique molding method eliminates all imperfections for smoother performance . . . longer life. Belts are individually boxed or packaged in sets to keep them in perfect condition . . . assure easy storage and identification. *Matched sets are guaranteed.*

Check your requirements for oil field rubber goods. Then insist on the best — NYB&P, sold *exclusively* through Continental. You'll save time by making your *first* stop the *only* stop . . . at the store with the big Green Triangle.

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. . and at Continental, hose stocks are matched by stocks of regular and special couplings for almost any application

- Rotary Hose
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- Discharge Hose
- Rig Washdown Hose
- High-Pressure, Wire Braid Oil Field Hose
- LPG Hose
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- Paint-Spray Hose
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- Steam Hose
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V-BELTS

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PACKING

- Rod Packing
- Sheet Packing
- Pump Packing
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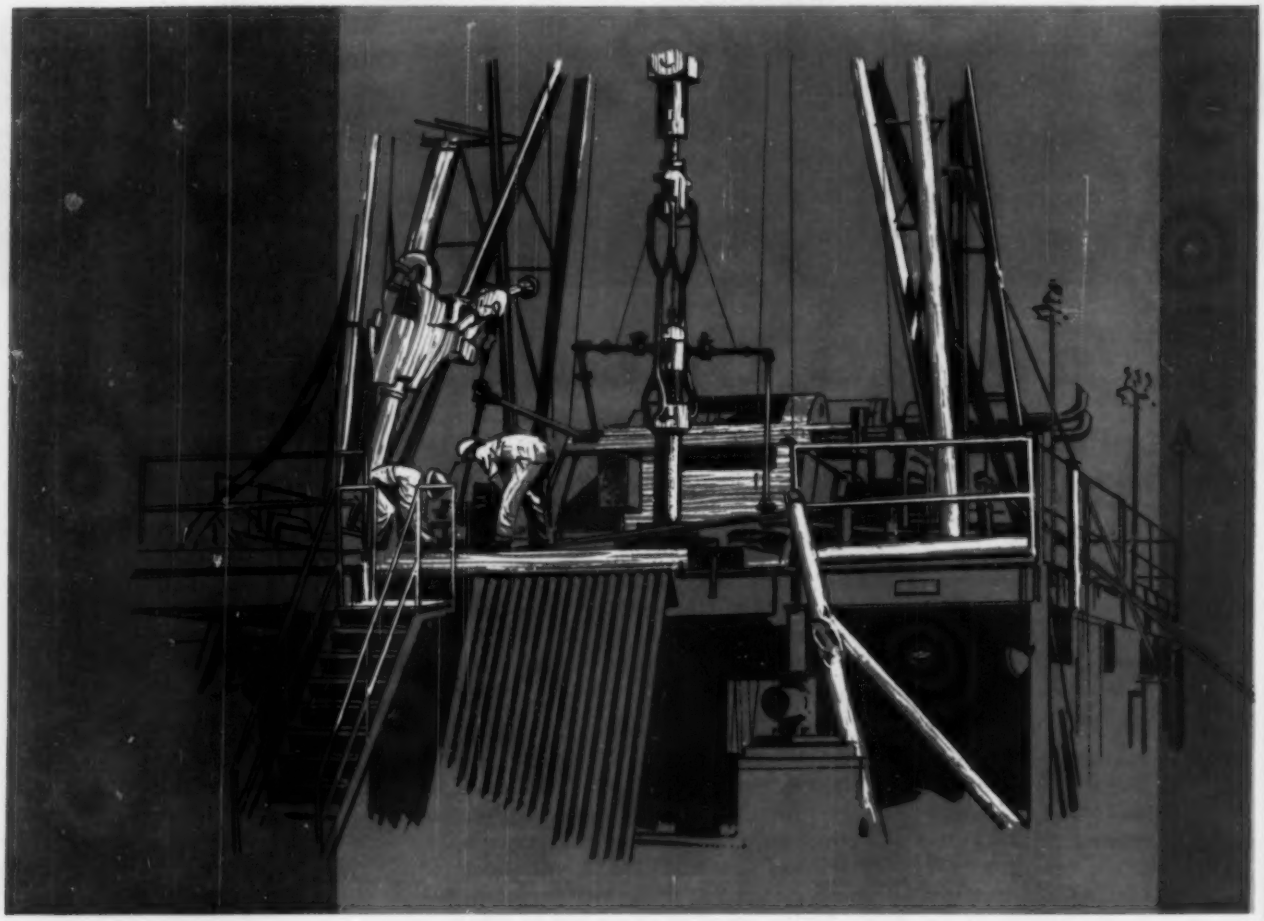
FOR BETTER COMPLETIONS...

CUSTOM DESIGN YOUR CASING STRING



Here is another way Halliburton helps you combat well completion problems. In addition to the multitude of special cements and additives—the advanced equipment—the skilled personnel . . . Halliburton also provides a complete selection of Casing Floating, Guiding and Self Fill-Up Equipment. From this large line of proven performers, you can custom design a cementing string that will best fit your specific requirements—everytime.

275 HALLIBURTON SERVICE CENTERS JUST MINUTES AWAY FROM YOUR WELL

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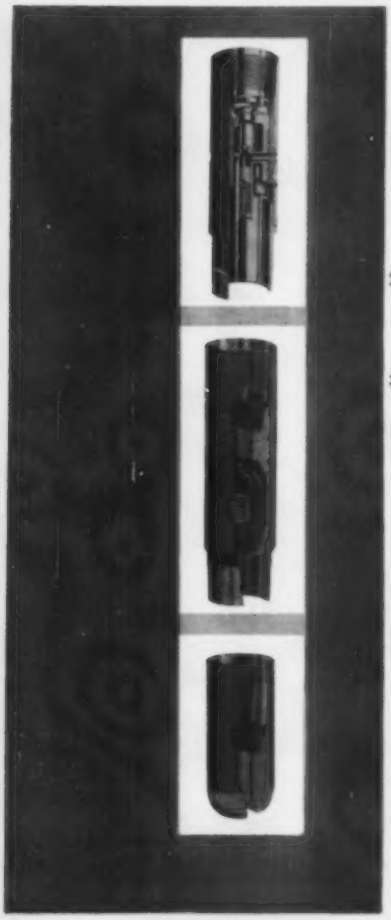
. . . with Halliburton FLOATING AND GUIDING EQUIPMENT



HERE'S A GOOD EXAMPLE: In completing a deep well in West Texas, one operator used three Halliburton tools on the string of casing to save time and money. He chose:

1. **THE SELF-FILL DIFFERENTIAL COLLAR**— to automatically fill the casing above the top float collar to maintain a balanced fluid head inside and outside the pipe . . . helping to protect the casing from collapsing.
2. **THE SUPER SEAL FLOAT COLLAR**— to provide a fluid barrier inside the string as it was run . . . taking part of the strain off of the derrick by partially floating the string to bottom.
3. **THE HALLIBURTON GUIDE SHOE** — to help direct the string away from ledges and other obstructions such as hard shoulders and crooked holes to minimize side-wall caving while running casing to bottom.

HERE'S WHERE SELECTION COMES IN: For wells where a medium range of differential pressure will be encountered, the operator could elect to use Halliburton's new INSERT SELF FILL-UP FLOAT VALVE instead of the Self-Fill Differential Collar as both perform similar functions. He could have substituted a less expensive INSERT FLOAT VALVE for the heavier-duty Super Seal Float Collar. In place of the Regular Guide Shoe, he might have used Halliburton's TURBO-JET GUIDE SHOE which is equipped with a fluid actuated rotor to provide high turbulence of cement slurry around the shoe — helping to keep the well bore clean and provide a better distribution of cement around the shoe joint. The Turbo-Jet Shoe is also available with a built-in back pressure float valve.

THE POINT IS . . . Halliburton has developed the tools that will best fit your specific well completion requirements. These described above are just a few of Halliburton's Floating and Guiding Casing tools. Your nearby Halliburton man can show you all the rest — and explain their many uses.

CEMENTING SERVICES

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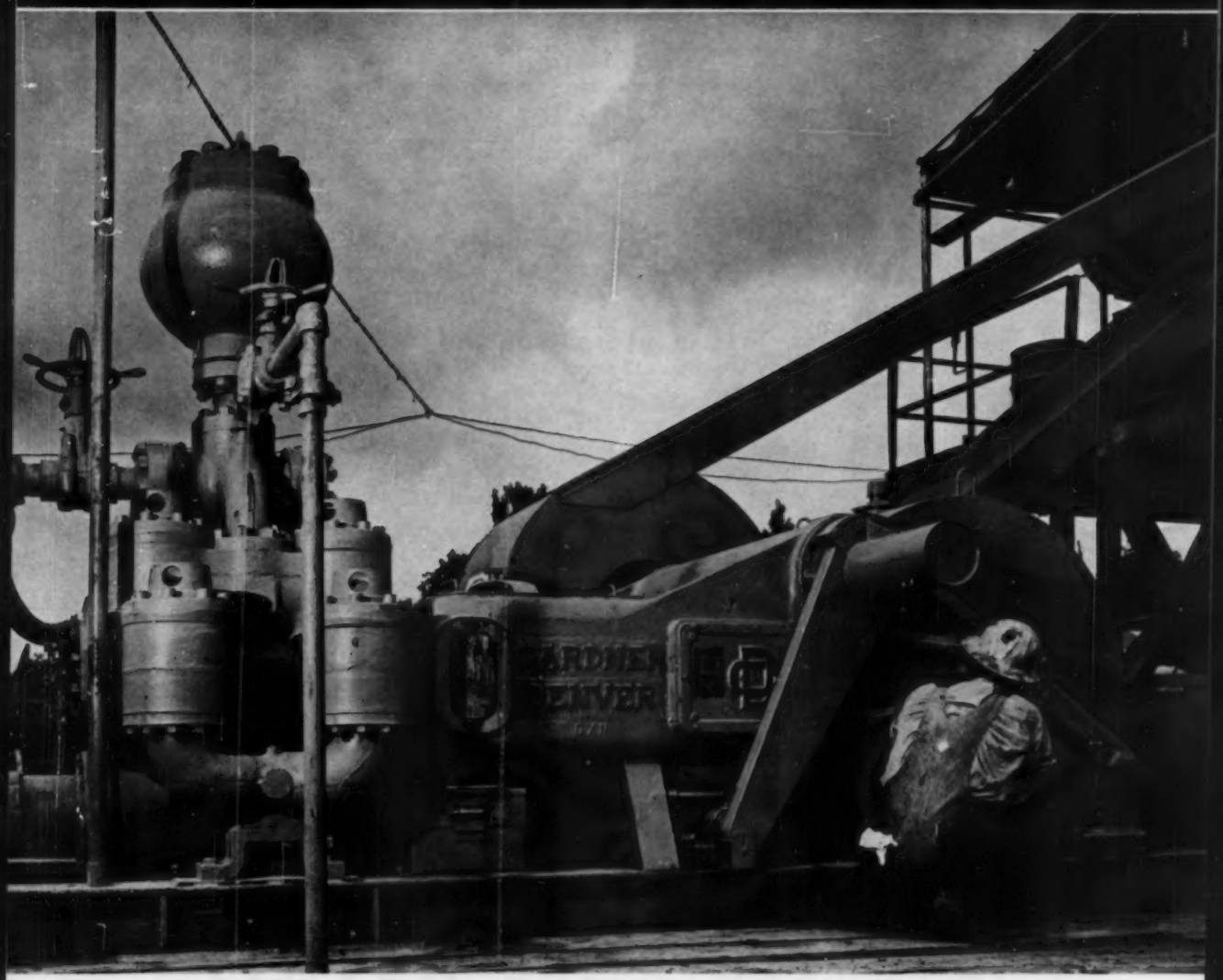
Gardner-Denver Mud Pump parts are easily replaced at the rig site. J&L Supply stores in the United States and Canada stock the parts. This is how to.....

Simplify



This GXN is one of two Gardner-Denver mud pumps in tandem arrangement on a wildcat in Louisiana. Gardner-Denver engineers designed these pumps for complete service in the field. And Gardner-Denver mud pump parts are as near as your J&L Supply store. Unitized, trailer-mounted, offshore—any rig with Gardner-Denver mud pumps is never handicapped for lack of experienced Gardner-Denver service or genuine Gardner-Denver parts.

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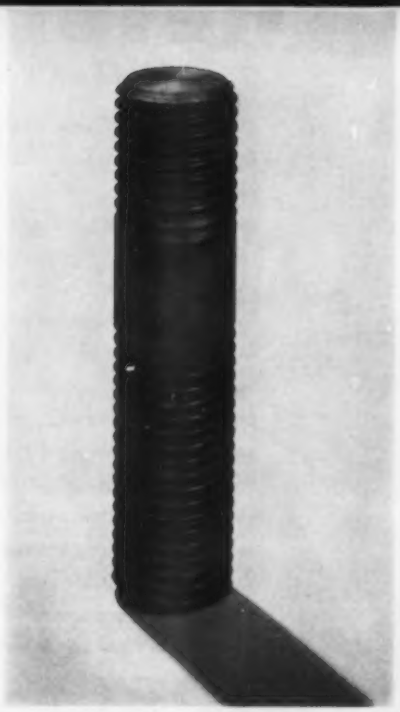
Mud Pump Maintenance



SAFEGUARD AGAINST RIG BREAKDOWN.

There is a difference in valve cap studs. Gardner-Denver studs are machined from alloy steel and heat treated.

To avoid costly failures, damaged equipment, insist on genuine Gardner-Denver parts. Protect your investment in quality.

Ask your J&L Supply man for literature on Gardner-Denver mud pumps in sizes to 1250 h.p. for drilling to any depths.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

If it's sold by J&L....It's the best available

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MID-CONTINENT SUPPLY CO.

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Mid-Continent "Supermarkets" have everything . . . including thousands of supply and equipment items plus SERVICES, too. Our supply service in the field includes handling orders or instructions through a two-way radio network from mobile to field store or office to quickly supply your requirements. Factory-trained personnel stand ready 24 hours a day to assure machinery field service . . . making repairs on location if possible. Field installation, an important sales service, is provided by qualified personnel for complete projects. Supplementing the sales organization, Mid-Continent's engineering staff offers technical assistance and designs equipment for your exact needs. And, for international customers, multi-lingual personnel are an important part of our organization. These are SUPERMARKET SERVICES! Your needs are quickly and economically supplied at the sign of the familiar neon derrick on your Mid-Continent "Supermarket" . . . a symbol of sure service around the world.

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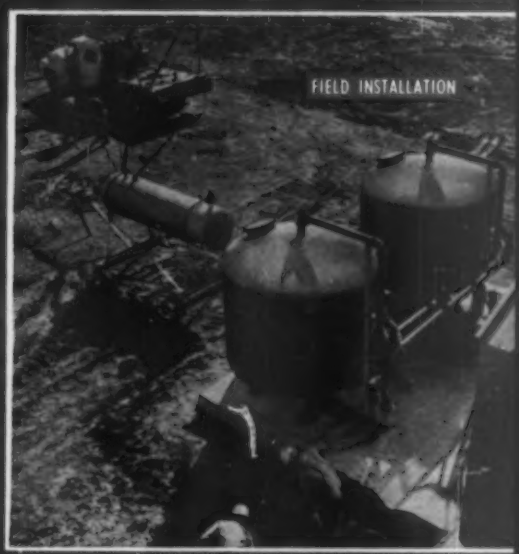
FIELD INSTALLATION

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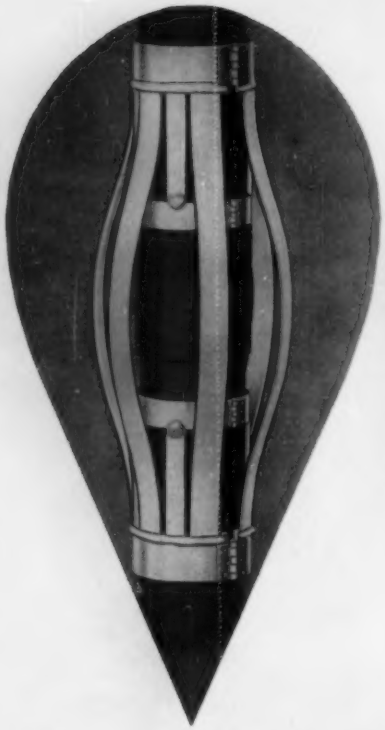
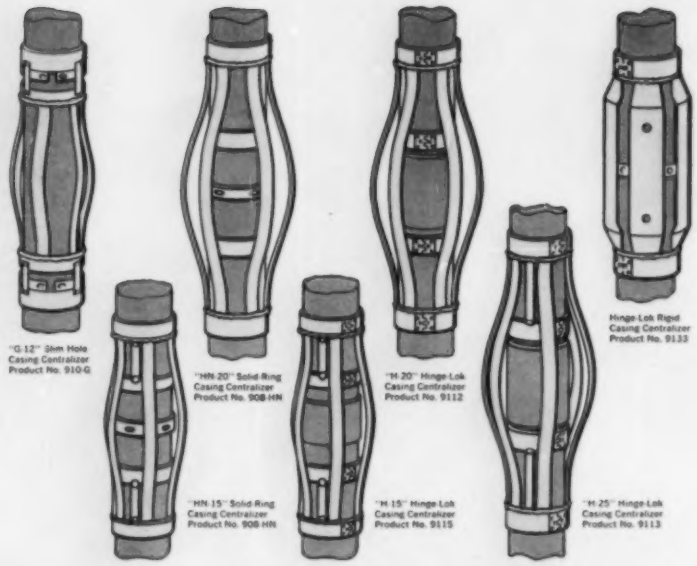
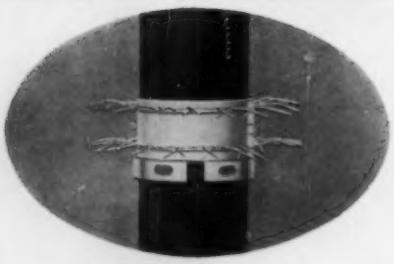
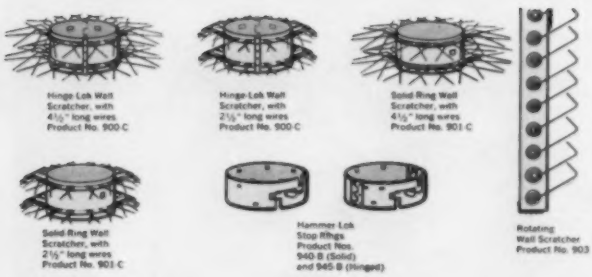



"G-12" Shm Hole Casing Centralizer Product No. 910-G
"HN-20" Solid-Ring Casing Centralizer Product No. 908-HN
"H-20" Hinge-Lok Casing Centralizer Product No. 911-2
Hinge-Lok Rigid Casing Centralizer Product No. 911-3
"HN-15" Solid-Ring Casing Centralizer Product No. 908-HN
"H-15" Hinge-Lok Casing Centralizer Product No. 911-5
"H-25" Hinge-Lok Casing Centralizer Product No. 911-3

A good cement job starts with two things




Hinge-Lok Wall Scratcher, with 4½" long wires Product No. 900-C
Hinge-Lok Wall Scratcher, with 2½" long wires Product No. 900-C
Solid-Ring Wall Scratcher, with 4½" long wires Product No. 901-C
Solid-Ring Wall Scratcher, with 2½" long wires Product No. 901-C
Hammer-Lok Stop Rings Product Nos. 940-B (Solid) and 945-B (Hinged)
Rotating Wall Scratcher Product No. 903

A good primary cementing job starts with centered casing and a good bonding surface. The only centralizers and scratchers good enough for this important job are the best ones you can get. That's where Baker comes in...

BAKER CENTRALIZERS are tough and resilient to withstand running-in forces. They are made in a wide range of spring-bow heights to provide one exactly right for your specific casing program. That's why when you're landed your casing has adequate clearance for good cementing. For installation convenience, Baker Centralizers come in both Hinge-Lok and Solid-Ring types.

BAKER SCRATCHERS glide down the hole without disturbing the mud cake; and when activated in the cementing area they dig in and remove the mud cake ensuring a good bonding surface. Baker Reciprocating Scratchers come with either long or short wires, in Hinge-Lok or Solid-Ring types. Baker Rotating Scratchers come in five-foot sections, and feature "plow angle" scratcher wires that are effective regardless of annular clearances.

NO WELD INSTALLATIONS of centralizers and scratchers are easier and better with Baker Hammer-Lok Stop Rings. Just a hammer blow locks one on. And they stay put because inserted teeth give them a much stronger grip than other friction-type stop rings.

Baker Primary Cementing Equipment is conveniently available at Supply Stores in the United States and Canada.

BAKER
CENTRALIZERS • SCRATCHERS

BAKER OIL TOOLS, INC.
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A special report:

The Well Servicing Contractor Today

LOWELL A. MURPHY, *Assistant Editor*

A survey of well servicing and workover contractors reflects the decreased activity throughout the industry . . . but holds a promise of better days ahead

MR. AVERAGE CONTRACTOR in the well servicing and workover business is not too happy about his situation today. His earnings this year have slipped a little from the level they reached last year, mainly due to a simple increase in the cost of doing business. He feels that he ought to be able to earn at least 15% net profit, but he would have to increase his prices 11% in order to realize this profit at his present level of activity.

He operates six rigs, most of them about 4 years old, and most of his work is done in tubing and rod jobs. Although he plans to spend less on new equipment next year than he did in 1960, he has some pretty positive ideas about what he wants.

He would like a smaller rig, preferably truck mounted and with a structural mast. He has already equipped half of his rigs with power tongs, but feels that there is considerable room for improvement in this relatively new tool. He's also anxious for a more reliable engine since this is the primary cause of his downtime. And a good set of automated slips would certainly catch his eye.

The average well servicing contractor feels that he has to pay too much for his insurance, but he's hoping to improve this situation through a well organized safety program.

His biggest problem is keeping his crews manned with competent personnel. He would like to pay his men more, but the unrealistic profit margin at which he has to operate makes it nearly impossible.

But in spite of all his problems and hardships — some of them common to all business and some of them uniquely his own — he is holding on to his rigs and to the conviction that things are going to be better for him during the next two years.

This composite picture of the average well servicing contractor was drawn from replies to a survey of contractors throughout the country made by *The Petroleum Engineer*. The survey followed closely the lines of a similar study made two years ago to find out more about this vital segment of the oil industry. Comparisons with the previous survey make this report even more interesting.

Questions in this report are grouped to show the contractors' financial picture, his equipment operations and

desires, and other general considerations. We feel that the entire report is of interest and value to anyone connected in any way with the growing well servicing and workover contractors.

THE FINANCIAL REPORT

We asked the contractors to look over their balance sheets for the last year and to give us the answers to some money questions. Here are their replies.

Are your 1960 earnings up or down?

Although the majority of contractors reports a decline in earnings from last year, the number with increased earnings has nearly doubled during the past two years. Survey replies indicate that 26% of the contractors will register higher earnings for 1960, as compared with only 14% making higher earnings as reported in a similar survey two years ago. 59% of the contractors report their earnings have decreased from last year, little change from the 61% with decreased earnings in 1958. 15% show no change in income, compared with 25% who held their own in 1958.

For those contractors with increased business in 1960, this increase in earnings averaged about 10%, against 9.2% in 1958. Those who reported decreased earnings made an average of 30% less than last year, a considerably bigger loss than the nearly 20% reported in 1958.

How much have costs increased?

The cost of doing business continues to increase in almost all phases of the well servicing industry. Contractors report the biggest boost in costs has come in equipment, with an average increase of 10% being reported. Labor costs have climbed 6% over last year's level. Overall cost increase for the contractors responding to this survey averaged 13%, while the corresponding overall figure reported in the survey made two years ago showed an increase of little over 8% over the previous year.

What is a fair profit?

Well servicing contractors have come down a little in the last two years on what they consider to be a fair net profit. In the 1958 survey, the average fair net profit was considered to be almost 17%. Now, the contractors set an average of 15% as a fair net profit. This figure is certainly reasonable and could not be considered exorbitant in any industry.

Do you earn a fair profit?

Although well servicing contractors feel that a net profit of 15% is reasonable, few of them are making this much. We asked the contractors how much they would have to increase their prices in order to realize what they considered to be a fair profit. The answers ranged from 0 to 25%, with the average at 11%. But most contractors have no plans to increase prices even 1%, in spite of the unreasonable profit margin at which they are operating. Their prices are set by the fierce and often unbusinesslike competition in which they are engaged.

What about 1961 purchases?

Well servicing contractors won't spend as much on new equipment in 1961 as they did in 1960, according to the survey. Only 18% of the respondents have budgeted more money for new equipment in 1961 than they did in 1960. 52% plan to buy less and 30% will spend about the same amount as they did last year.

Some contractors are still using up surplus equipment that they bought back in what one contractor terms "the good oil days." Others have created spare parts stocks out of idle rigs which are providing replacement parts for their operating rigs. And, sadly, there are too many rigs running today that are simply not equipped or in shape to be doing a safe, efficient job. These are some of the reasons that well servicing contractors are not buying equipment as fast as they are using it up and wearing it out.

Do you employ an accountant?

Well-kept records can be one of the most important tools any business man has for spotting and correcting profit leaks. An efficiently operating piece of equipment might be easily overlooked unless all repair and maintenance costs are recorded together to give a complete picture of the equipment's performance. Thorough analysis of good accounting records can help spot poor purchasing practices, unsound operating methods, or even unproductive personnel.

Most well servicing contractors, even the very smallest, realize the importance of good financial records. Only 6% of the contractors replying to this survey indicated that they do not employ an accountant. 26% of the contractors have accountants working full-time and 68% employ part-time accounting help.

THE EQUIPMENT PICTURE

In order to find out what equipment the contractors are operating and what they would like in new equipment, we asked the following questions.

What work do your rigs do?

Although some contractors are fairly specialized in the type of work they are equipped to do, nearly half of all rig work is in common tubing and rod jobs. Averages show that 47% of rig work is in tubing and rod jobs, 36% in workovers, and 17% in swabbing jobs.

It is interesting to note that these figures have changed almost none at all from the averages reported two years ago. At that time, contractors reported that 48% of their work was in tubing and rod jobs, 35% in workovers, and 17% in swabbing jobs. Of course, then as now, these figures vary widely from contractor to contractor and from region to region, but they do reflect a fairly constant distribution of work throughout the U. S.

What is average servicing depth?

The average depths at which well servicing contractors work have remained almost constant over the past two years. In 1958, contractors reported that their average swabbing jobs were from a depth of 5900 ft; the present figure is 6200 ft. Average tubing and rod jobs two years ago were at a depth of 5600 ft and are now reported at 5500 ft average. Workover depths have remained unchanged at 6200 ft, according to the two surveys.

Of course, drilling has gone deeper during the past two years, but due to the decrease in drilling activity and the fact that the relatively new wells do not need servicing or workover, the average servicing depths have not yet followed the deeper trend. Also, operators have been concentrating on keeping their older wells operating efficiently due to their limited development budgets. There is little reason to assume, however, that well servicing and workover operations

will not reflect the trend to deeper drilling in the next two years.

What about rig dimensions?

Well servicing contractors are asking for smaller rigs than they requested two years ago. Road laws are, of course, the primary governing factor in rig size, but the contractors are also concerned with weight and portability of their rigs. We asked the contractors what they consider to be the ideal dimensions of a servicing rig. Their replies indicated an average length of 44 ft, compared with an average of nearly 50 ft two years ago. Then as now, an average width of 8 ft was considered to be the maximum, with this width being set in most areas by state law. Height of the ideal rig would be little over 12 ft, just short of the height specified by contractors in the 1958 survey.

The trend to lighter, more portable well servicing rigs is underlined by the decrease in weight desired by contractors over the past two years. In the 1958 survey, contractors said that the average servicing rig should weigh no more than 60,000 lb. Now, the figure is down to 52,400 lb.

How should rig be mounted?

Some contractors are very positive about what type of rig mounting they prefer while others do not seem to have a preference. Contractors were asked to indicate their preference of the three commonly used methods of mounting well servicing equipment: truck mounted, trailer mounted, or mounted on a self-contained chassis. 50% favored the first, only 8% preferred the second, and 42% indicated the third.

Compared with the 1958 survey, the present report shows that the self-contained unit has almost doubled in popularity from 22%. Two years ago the truck mounted unit received 50% of the vote and the trailer mounted unit was preferred by 8% of the contractors.

Where should hoist power be?

On truck mounted units, power to run the hoist can be taken either from the truck engine or from a separate engine located near the hoist. Asked to indicate a preference between the two systems, contractors were 69% in favor of a source of power separate from the truck engine and 31% in favor of using the truck engine.

Do you use power tongs?

As contractors look for new and more efficient equipment to help them do a more profitable job, the use of power equipment has risen. Increased use of power tongs has been especially in evidence during the past two years. Response of our survey shows that more than half the well servicing rigs now operating (54%) are equipped with power tongs.

Some contractors feel that they can take full advantage of power tongs without equipping each of their rigs with a set of tongs by letting one set serve more than one rig. In fact, our survey shows that each set of tongs in the field serves an average of 1.8 rigs. However, one contractor has provided power tongs for each of his 28 rigs.

Are power tongs practical less than 3000 ft deep?

One criticism of power tongs has been that they do not save enough time to make them practical for work less than 3000 ft deep. We asked the contractors for their opinion on this question and found that 68% of the respondents believe that power tongs do have an advantage at this relatively shallow depth.

How old is your equipment?

We asked the well servicing contractors to tell us the age of the majority of their equipment. For 29% of the contractors, most of their equipment is from 1 to 3 years old. 51% of the respondents have had their equipment from 3 to 5 years. 20% are operating with a majority of their equipment over 5 years old.

By most industrial averages, equipment in operation from 3 to 5 years is not considered old. But well servicing and workover equipment probably has a shorter working life than that enjoyed by most industrial equipment. However, these age figures do reflect the sharp decrease in purchases during the past three years.

How many rigs have you junked?

The rate of junking rigs has decreased considerably in the past two years. The 1958 survey showed that there was an average disposal rate of 0.36 rigs per contractor for the year. In 1960, contractors junked their rigs at a rate of only 0.12 per contractor, while they sold rigs at an average of 0.44 rigs each.

As with all statistics, these figures could be used to reach many different conclusions. Probably most valid is the observation that, in view of decreased purchases, contractors are less disposed to junk their older rigs.

What equipment most needs improvement?

Contractors took a look at their equipment and decided that a relatively new tool—power tongs—has the most room for improvement. 21% of the respondents named this piece of equipment as the one which most needs improvement, realizing of course that power tongs have been developed and improved tremendously in the past two years.

Next in line, better brakes were called for by contractors. Two years ago, this item lead the list in least satisfactory equipment.

Pumps and power trains came next on the list of equipment needing improvement. In addition, contractors expressed a desire for better derricks, hoisting drums, swab line lubricators, and trucks.

What type mast do you prefer?

Fifty-nine percent of the well servicing contractors indicated a preference for the structural mast over the pole mast. Does this mean that the majority of well servicing rigs sold from now on will be equipped with a structural mast? Probably not. Typical of several comments made on the subject is the statement by one contractor that, although he can do a better job with a structural mast, he just can't afford this generally more expensive piece of equipment with the profit margins at which he is operating.

What about automation?

Automatic equipment for the well servicing field has received continually increasing attention during the past two years. We asked the contractors what piece of equipment they would most like to have automated and 40% of the replies indicated a desire for automatic slips. Next, 22% would like to have an automatic system for racking rods and tubing.

Among other equipment and procedures that contractors want automated are casing tongs, swabbing operations, drawworks, and the tilt on the mast.

What's holding up well servicing equipment automation? It isn't the technical ability of the manufacturers that has

prevented the development of a completely automated rig. It is the ability of the purchaser to pay for the resulting equipment. But as the manufacturers continue their work in developing efficient automatic equipment and more and more well servicing contractors are able to use the equipment in the field, automation will enjoy a more widespread and practical application in the field of well servicing and workovers.

What causes rig downtime?

Rig downtime can be one of the most costly phases of a contractor's operations and can result from many different causes. Mechanical repairs often cost much more in lost time than in replacement parts and labor. The rugged machinery sold by most manufacturers today have practically reduced this type of downtime to a minimum, but a relatively few pieces of equipment still are the source of most trouble for the contractors.

The most common source of trouble leading to downtime is the engine, according to 32% of the contractors. Engines were indicated as the leading source of trouble in the 1958 survey, as reported by 44% of the contractors questioned.

Maintenance and minor repairs were cited by 27% as the next most frequent cause of downtime. Other trouble spots mentioned by contractors were tongs, pumps, brakes, and chains.

OTHER CONSIDERATIONS

Do you keep permanent well records?

Permanent well records can be valuable to a contractor as well as to his customers. Contractors can use them to evaluate their own performance and as a quick reference to field conditions. Some customers use the contractor's records as their own permanent file.

In this survey, 75% of the contractors indicated that they keep permanent well records, 22% keep no records, and 3% keep partial well records of their jobs.

What about safety programs?

More and more well servicing contractors are beginning to realize the extreme importance of a well organized and applied safety program. Among the immediate benefits resulting from sound safety practices are more favorable insurance rates and higher morale and increased performance from the crews.

Of the contractors we contacted in this survey, 53% have a definite safety program in operation. This, of course, includes most of the larger concerns, but even many one-rig contractors are striving to make their operations more efficient through sound safety practices.

Is insurance reasonable?

We asked the well servicing contractors if they felt that insurance available for their equipment and operations was at reasonable rates. 55% of the contractors responded with an emphatic "No." After talking with many contractors around the country, we were frankly surprised that this figure resulted as low as it did.

As with all insurance, the cost of coverage available to a well servicing contractor is affected by the experience of his industry. There are, therefore, some inequities between the contractor who has never had to make demands on his insurance and the contractor who has collected compensation far in excess of the premiums he has paid. But as the industry experience continues to improve and as the insurance companies take more into account the record of the individual contractor, available insurance will more nearly match the fair requirements of the individual contractor.

What is your greatest problem?

The long list of problems that plague well servicing contractors is topped by one that accounts for nearly half the contractors' miseries — personnel. 48% of the respondents indicated that labor is their biggest problem.

Unreasonably small profits were named as the next most common problem, accounting for 18% of the replies. Closely allied with this complaint is the next most common problem, unrealistic competitive bidding, which 15% of the contractors state is their biggest problem.

The list continues to include what one contractor called "the despicable business of payola," or kickbacks paid to an unscrupulous representative of the customer by an equally unscrupulous representative of the contractor. Also mentioned was inadequate supervision by the customer, high cost of maintenance, difficulty in obtaining production income, and the high cost of insurance.

What about next two years?

Although many industry barometers point to an increase in well servicing and workovers during the next two years, only a bare majority of the contractors surveyed are in agreement. Just 51% look for an increase in their activities. Of course, a sizeable increase by some of the more active contractors will offset a decrease by a greater number of smaller contractors.

It seems logical to expect that well servicing and workovers will increase. Crude demand, both domestic and for export, is definitely going up and well servicing and workover jobs are certainly tied to production levels.

SUMMARY

If another survey similar to this is made at the end of two more years, we will certainly find that many contractors will be working with some of the same problems they have now. Some contractors will have had great success while others will have found themselves no longer able to compete and out of the business. A careful analysis of his own operations and those of his competitors as reported in this survey will help any contractor insure his share of future activity.

Likewise, the manufacturer who has the equipment that the contractor wants and needs and is able to pay for will certainly benefit. Equipment development has been quite impressive during the past two years, especially in the field of small tools designed specifically for work in slim-hole and tubingless completions. Many such tools have become standard off-shelf items designed to do the job formerly done by modified or shop-made tools.

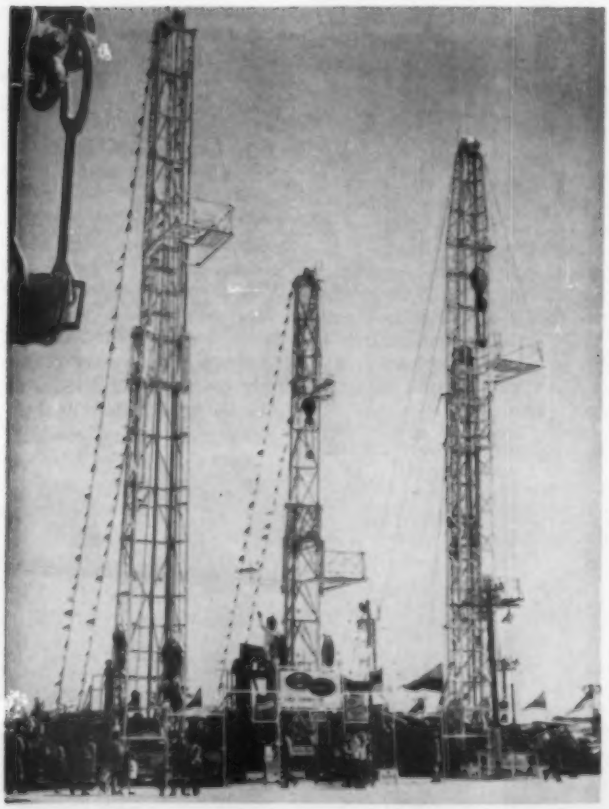
Finally, operators should look closely at their relationships with the well servicing contractors, especially in the areas of evaluating bids and awarding contracts. It is certainly true that the lowest bid will not necessarily result in the most economical job.

While we realize that the operating experience of any one individual contractor might not agree directly on any point with the statistical averages presented in this study, we do believe that anyone associated in any way with the well servicing contractors can benefit from a careful perusal of this report. It is especially hoped that oil producers and manufacturers will make themselves more acquainted with the activities and needs of this important segment of the industry. * * *

Well Servicing and Workover . . .

Highlights of the Permian Basin Oil Show

A visit by The PETROLEUM ENGINEER staff to the Permian Basin Oil Show produced a quick scan of interesting ideas for this special issue to give operators or superintendents responsible for maintaining producing wells and contractors who perform well servicing or workover jobs a view of some latest equipment developments.



Assembly of well servicing and workover rigs and equipment included, left to right, Franks Explorer Rocket 658 DTD-HT, Franks Tri-Scope Derrick Explorer Rocket 658 DTD, and a Wilson Super 38 Model Winchmobile with automatic equipment.

Oil Show Dedicated To Well Servicing Contractor

The mammoth Permian Basin Oil Show was dedicated to the owner of one of the largest well servicing companies in the world, J. P. "Bum" Gibbins of Midland, Texas.

Dedication ceremonies were held on the opening day of the show, October 20, and a mile-long downtown parade was held before the dedication to get the oil festivities underway.

In announcing dedication plans, officers of the show said: "J. P. 'Bum' Gibbins is recognized and respected as one of the pioneers in the Permian Basin oil industry. His tireless work and many contributions to the business have helped make this area one of the world's leading producers of oil."

Gibbins is president of J. P. "Bum" Gibbins, Inc., an oil well service company with units in all major producing areas in the Permian Basin, employing some 500 men.

A native Texan, Gibbins' first business venture was in Burkburnett in 1919 when he purchased a team of mules for oilfield work. He later hired a team driver and worked for himself as a rig builder, roustabout, and tool dresser.

From Burkburnett he went to Cross Plains where he worked for J. S. Cosden as gang pusher and rod and tubing machine operator. He was made production foreman by Cosden after being with the company only six months.

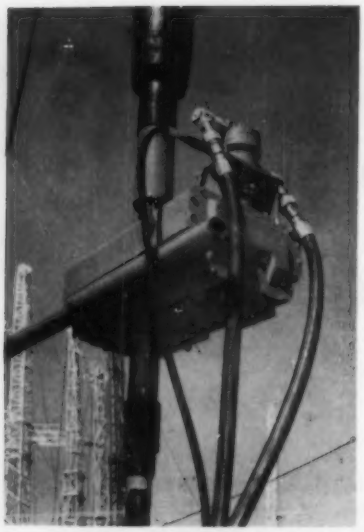
Later, Gibbins went to the famed Yates field of West Texas, working as a rig builder for contractors.

In 1935 Gibbins & Heasley was formed as the first oil well servicing company in the Permian Basin. Gibbins purchased Heasley's interest in 1938 and the firm continued to grow through the years. The company purchased from two to four servicing units each year and by 1946 added rotary and cable tool workover rigs for drilling and completion operations.

Fred E. Cooper TC 38-38 Unit with Hydra-Sub

TC 38-38 unit manufactured by Fred E. Cooper, Inc. of Tulsa, Oklahoma

Fred E. Cooper's TC 38-38 rig ...



... equipped with Cooper Hydra-Sub.

showed company's recently-developed Hydra-Sub which uses available hydraulic power to rotate drill string during workovers and drilling.

Rated at 8500 ft of 2.5-in. tubing, unit has 38-in. tubular drum brakes and is available with pole or derrick mast. A variety of engines can power the rig, and torque converter drive can be used.

Hydra-Sub is positioned on the drill string just under the swivel and on top of the drill pipe. As the hydraulic power is delivered through hoses, the sub is free to move up and down in the derrick.

This gives flexibility for fishing tool, workover, or drilling operations. Torque arms traveling on the stabilizing lines in the derrick prevent the hydraulic sub from rotating with the drill string.

Any standard swivel can be used with the system.

Wilson Winchmobile Rig With Automatic Equipment

Progress in streamlining workover operations has been accomplished by Pool Well Servicing Company of San Angelo with six automatically-operated Wilson Winchmobile rigs which have been used for two years in West Texas and the Oklahoma Panhandle.

Operated by three crewmen instead of the usual four, the rig features automatic slips and tongs. One crewman controls the drawworks and operates the automatic slips. These slips are designed also to provide back-up on the casing being run or pulled.

A single floorman without a rotary helper operates the automatic hydraulic tong drive system and helps rack pipe. These tongs have an attachment to back-up the collar if it breaks, and controls on the tongs permit the single floorman to perform the operation with no greater effort than if job were performed by two men.

The derrickman performs the usual function of placing and racking pipe in the derrick.

The derrick reduces pulling time by pulling tubing in doubles and rods in triples. Swinging rod rack and folding platform for derrickman aids this operation.

Automatic equipment is mounted on a Super 38 model Winchmobile of Wilson Manufacturing Company, Inc. of Wichita Falls, Texas.

The 57,560-lb unit with engine cross-mounted rather than lengthwise on the frame, has a rated capacity of 8000 ft of 2½-in. tubing.

The 90-ft fabricated angle-steel mast has a 260,000-lb capacity and requires no ground guy lines for ordinary loads. Two outriggers for the mast provide side bracing.

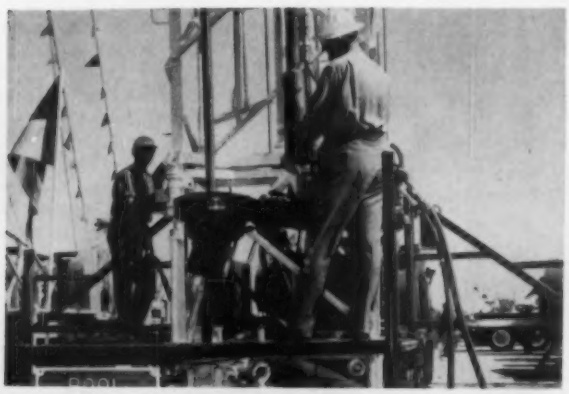
Cross-mounted engine requires only two chain drives, one from the converter to the countershaft, and another from countershaft to the hoisting drum. A standard four-speed and reverse transmission is used.

Unit has both a high and a low speed friction clutch drum drive for speed in handling light loads and capacity to handle heavy loads.

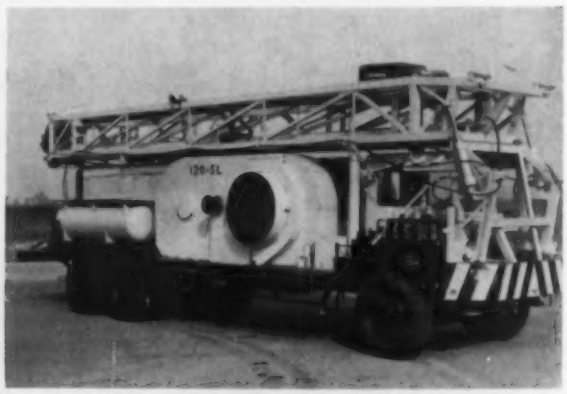
Air controls are mounted on a separate panel on the side of the mast. Controls include a lower drum clutch valve, an upper drum clutch valve, a hand throttle valve and cathead control valve if needed. A foot throttle is also provided.

All drums are equipped with rolled-alloy steel brake rings, and the lower drums can be furnished with spray or circulating water cooling. Unit uses a lever-type brake with double-bell crank-type equalizer.

Both front and rear axles steer to prevent dragging tires. Rear axles are double-reduction type with power divider.



Pool Well Servicing crewman operates drawworks and automatic slips while another controls automatic hydraulic tong drive. These Foster Cathead Company tongs, also displayed at the show, speed making and breaking stands of rods and tubing.



Bucyrus-Erie Model 120-SL.

Crewmen give Franks Tri-Scope derrick check-over during show.

Optional equipment on Tri-Scope derrick includes tubing racking board, combination rod board and hangers, automatic folding of racking board, raising of rod board, air lift rod transfer.

Lowering dual traveling block on IDECO Model 302 Drive-In Rambler Rig . . .

Bucyrus-Erie Model 120-SL Mobile Servicing Rig

A new lightweight mobile servicing rig developed by Bucyrus-Erie Company of South Milwaukee, Wisconsin and displayed at the oil show was the Model 120-SL, designed for well servicing and rotary workovers to 12,000-ft depths.

In designing the unit, special emphasis was given to such field needs as bigger, sturdier brakes, increased engine power and load capacity, and combined over-the-road and drive-in mobility.

The 120-SL incorporates such features as rugged, compact drive-in type construction with power steering, air brakes, complete road visibility from one-man cab, heavy-duty drawworks construction, fully-synchronized transmission with air-assist shift and remote control, hydraulically raised and extended structural steel 67-ft mast with 180,000-lb hook load capacity, and sturdy structural steel frame.

Drawworks embodies identical interchangeable main and sand line drums; oversized, hydraulically-equalized brakes that can be adjusted in one to two minutes without leaving the operator's station; detachable hardened brake flanges; enclosed-in-oil drive chains; and outboard-mounted air clutches.

For over-the-road travel, the telescoping derrick folds down over the rectangular carrier, and the machine's 25-ton weight is distributed over three heavy-duty axles.

Franks Introduces Triangular Telescoping Derrick

New, triangular, telescoping derrick developed by Franks Machinery Division of the Cabot Corporation of Pampa, Texas was on exhibition. Known as the Tri-Scope Derrick, the structure has been designed to provide greater strength with less weight. Minimum guying is required and greater speed of operation is obtained with automatic features.

The Tri-Scope Derrick Franks Explorer Rocket 658 DTD was designed for torsional stability from triangular cross-section and closed triangular bracing in all derrick faces. This reduces twisting and shaking in the derrick under severe loading and impact conditions.

Standard crown provided on the rig allows a four-line string to the block without crossing lines. Use of an offset sheave on the back side of the crown makes this possible. It also eliminates block twist.

Standard equipment includes the derrick (basic structure), crown assembly with optional line size, offset crown sheave with optional line size, crow's nest ladder, front guy lines to vehicle, pawl-locking mechanism, hydraulic raising system, fast line and dead line tie-back spool, tilt indicator gage, tilt lock assembly, and block cradle.

Optional equipment includes the tubing racking board, combination rod board with rod hangars, automatic folding of racking board, automatic raising of rod hangars, automatic raising of rod board, air lift rod transfer, adjustable working platform, derrick lighting system, catline sheave, and derrick racking board.

Derrick displayed was the 69-ft model, and a 90-ft model is also available. Each will be furnished with original equipment or installed on present equipment.

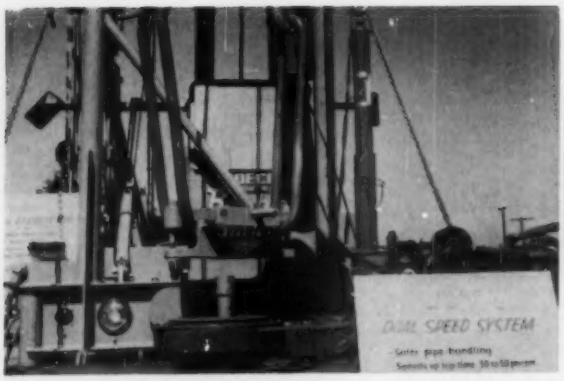
Roading length is 56-ft, API static-rated hook load with four lines is 100,000-lb with a four degree tilt angle on both derricks. Racking capacity of the 90-ft derrick with double stands of tubing is 2-in. EU, 16,500-ft, and 2½-in. EU, 13,500-ft.

Other rig displayed was the Franks Explorer Rocket 658 DTD-HT with a 396-hp diesel engine. Its 225,000-lb capacity 96-ft derrick has a two to one safety factor. Right angle gear box delivers the power for a 40,000-lb single-line pull, with drum clutches.

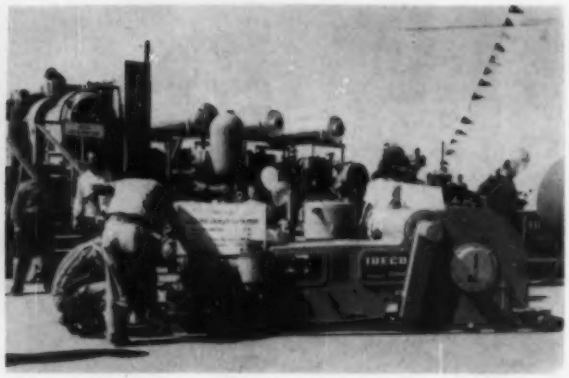
IDECO Introduces Dual Speed System

IDECO of Dallas, Texas introduced a dual speed system for workover rigs at the show. System was developed to decrease the actual tripping time required coming out of the hole and going into the hole with a string of tubing or drill pipe.

System utilizes a split traveling block, special elevators which remain around the tubing at all times, and a hydraulically-operated sub elevator which transfers the tubing to and from the racking area. This special arrangement permits the traveling block and elevators to move up and down in a continuous operation, not having to wait at the racking platform elevation while the tongs are spinning out or making up a connection.



. . . brings block to derrick floor to become part of dual-speed system. Power tongs speed connections during this continual-handling operation.



Compact slush pump IDECO designed specially for workover rigs.

Driller operates hoist and actuates air slips with a foot valve. Derrickman attaches sub elevator and guides tubing to and from the racking fingers. Tong man operates power tong and actuates hydraulic cylinder which raises and lowers sub elevator by means of a control valve mounted on the tongs. Floor man racks tubing on floor and dopes threads.

Advantages, IDECO says, are safer pipe handling and speeding trip time 30 to 50%.

Dual speed system was displayed on an IDECO Model 302 Drive-in Rambler rig with a forward-mounted Kwik-Lift mast. The mast is hydraulically raised and quickly telescoped, then lowered to transporting position without disassembly and with all reeving and guylines intact. Carrier and equipment are completely integrated, and one engine, one torque converter, and one transmission serve for both propulsion and rig operation.

Model KM90 Kwik-Lift Mast on the rig has a clear height from the ground of 90 ft; maximum rated static hook capacity with six-lines, 180,000 lb; four 24-in. crown sheaves; and an 18-in. sandline sheave.

Total racking capacity with 2½-in. tubing in 60-ft stands is 13,440 ft. Highway length of the unit is 50 ft, height, 13 ft 6 in.; width, 8 ft. Total weight of the mast, headrest, erection equipment, ram, safety lines, hinge support, and hydraulic plumbing is 18,910 lb. Nominal gross column capacity is 300,000 lb.

Driller's control panel is located in conventional position on hoist. An alternate control panel position is available with the panel located at the base of the mast with the driller standing on the ground.

Also displayed was a scaled-down slush pump for workover rigs which IDECO recently developed. Pump is MM 200 duplex slush pump. It has a maximum liner size of 6¾ in.; a stroke of 10 in., and maximum working pressure of 2000 psi. Weight with expendables is 11,079 lb.

Cardwell KM250 Drive-In Workover, Servicing Unit

Cardwell Manufacturing Company's KM250 Drive-In Rig is a rugged, drive-in type of servicing and workover unit for operation in the 7000 to 12,000-ft range with 2½-in. tubing. Its double-drum hoist and specially-designed carrier can be powered by a variety of oilfield power units in combination with a converter and three-speed transmission.

Hoisting drum features double-end drive and low clutch for easy accessibility. This clutch is specifically built to withstand the severe hoisting-clutch applications normally found in heavy-duty equipment.

Double-end drive lets the operator freely select the hoisting speed and line pull best-suited to his load for smoother handling with less shock loading.

High-strength structural telescoping masts greatly increase the versatility of this heavy-duty traveling rig. Most applicable are Cardwell's 90-ft and 96-ft versions, with respective hook-load capacities of 170,000 lb and 180,000 lb.

Specifications on the main drum, which is constructed of cast steel and heavily ribbed to insure proper bearing alignment, include barrel diameter, 16-in.; barrel length, 37-in.; drum-end diameter, 45-in.; brake flange diameter, 44-in.; brake flange width, 9½-in.; and effective braking area, 2214 sq in. Drum is free-spooling to permit the blocks to fall quickly during normal operations.

Combination of three-speed transmission, torque converter, and double-end drum provide an infinite number of hoisting speeds. Clutch is outboard-mounted for easy accessibility, and brakes are self-energizing and fully equalized with single-point adjustment.

Cast-steel sand-line drum is ruggedly-constructed to prevent spreading of drum ends under full spooling stresses. Drum is free-spooling and has a spooling capacity of 15,650 ft of 9/16-in. line. Three speeds forward and one reverse are available to sand line drum.

Cardwell masts available include 90-ft, 96-ft, and 80-ft telescoping structural masts.

An optional feature just developed consists of two front-axle dual wheels which rotate independently at a different speed, thus eliminating drag and tire wear. This maintains the maneuverability of single wheel axles. Feature allows a heavier legal rig load, minimized surface damage on lease roads and lightly-constructed access highways. It prevents sinking-in on soft terrain and in the area close to the well.

Lee Engineering Truck-Mounted Unit

Recently-introduced truck-mounted workover unit with 95-ft, 187,000-lb mast manufactured by Lee Engineering Company of Beaumont, Texas has a gross column capacity of 307,000 lb. Its API hook load capacity is 187,000 lb with six lines. Unit pulls 15,000 ft of 2½-in. tubing.

Unit features clear visibility between operator and derrickman, and torquing of mast is minimized by wide spread of guy lines in mast crown combined with inherent rigidity of box-girder type legs. Particularly lightweight mast is possible because load-transfer latches between upper and lower sections keep load in center of mast at all times. Mast offers hydraulic tilting and telescoping, eliminating need for external guy lines in either operation.

Road dimensions are 54-ft long and 8-ft wide, and crown consists of five 24-in. sheaves mounted on double roller bearings. Mast has a racking plat-

Cardwell KM 250 Drive-In Rig.

form with folding handrails, also. Base of mast has a built-in deadline anchor and leveling jack screws. Outriggers on each side of the mast base have self-leveling base plates.

Guy lines extend from top of mast to front of vehicle, and from top of mast to racking platform, but no middle guys are required.

Right-angle gear box made by Lee for the drawworks is capable of operating under 350 hp. Brake dimensions are 42-in. diam and 10-in. wide.

Pyramid "69" Trailer-Mounted Mast

The Pyramid "69" trailer-mounted mast, hydraulically erected and telescoped, with a 150,000-lb hook load, was displayed by Norvell-Wilder Supply Company and its manufacturer, both of Beaumont, Texas.

Built of angle steel, Pyramid's 13,500-lb mast has a crown block consisting of three 24-in. diam sheaves, with space for two more sheaves. Traveling block of three 48-in. by 30-in. sheaves hangs with flat side toward mast. Mast requires only back guy wires, and Y base has two lateral-stability outriggers. Hydraulic ram lowers the mast and wireline winches take up slack on back guys.

Unit has road height of 13 ft 6 in., with a 10-ft 5-in. width, from cathead to cathead, and over-all length of the trailer with mast is 37 ft 0 in. Rod hangers have two sets of adapter sleaves, and an air-lift system transfers the rods.

Drawworks is powered by an engine with torque converter. It has an oil bath chain guard and a drum grooved for ⅞-in. diam wire line. A dual-tandem trailer supports the equipment.

Strain Meter For Remedial Wireline Operations

Sidco Model T-1 strain meter displayed, a 2000-lb capacity weight indicator, is an electronic, direct-reading instrument for accurately measuring strain or weight on remedial wireline and other types of lightweight "downhole" cable operations.

A dual-range unit, meter is equipped with a low-range scale which records from 0 to 1000 lb, and a high-range scale which records from 0 to 2000 lb.

Completely transistorized, unit gives instantaneous response and operator is able to maintain constant control of any cable operation. Unit has infinite resolution with no hysteresis problem, no friction because unit is non-hydraulic. Battery case supplies all the power needed, and one set of batteries provides up to 500 hours of operation.

Two types of sensing cells are available, one which measures strain on a wireline and another compression-ring type that fits under a leg of a portable well servicing rig.

This safety device detects hangups in the hole, feels packers when they are hit. Plastronics Division of Plastic Applicators, Inc., of Houston manufactures the unit.

At the oil show, demonstrations of Halliburton's gas-turbine powered fracturing truck gave visitors a first-hand look at the unit in operation.

Halliburton's Jet Fracturing Unit After Tests

Halliburton Company showed its fracturing unit powered with a General Electric Company Model 720 gas turbine after it had successfully fractured two wells in field tests. This first field use of a gas turbine engine on a mobile oil field service unit was performed on two wells in the Santa Fe field of Stephens County, Oklahoma, immediately before the show.

Unit consists of a conventional truck base mounting a standard Halliburton HT-400 pump, powered by the 900-hp axial-flow turboshaft gas turbine engine. The turbine shaft's speed hits 19,500 rpm at 1050 hp maximum at 60 F, Joe Arnold, engineer in Halliburton's Mechanical Research and Development Department, said. Initial high rotating speed is lowered to 2806 rpm by a single stage reduction, then a six-speed transmission coupled to a worm gear reducer inside the pump provides a maximum of 393 rpm.

After evaluation tests have been performed with this unit, Arnold said, two units per truck will probably be used. Present unit has operated since July 1 in the laboratory and, including field tests, it will probably operate for a year before a final decision is made on putting gas turbines into general service.

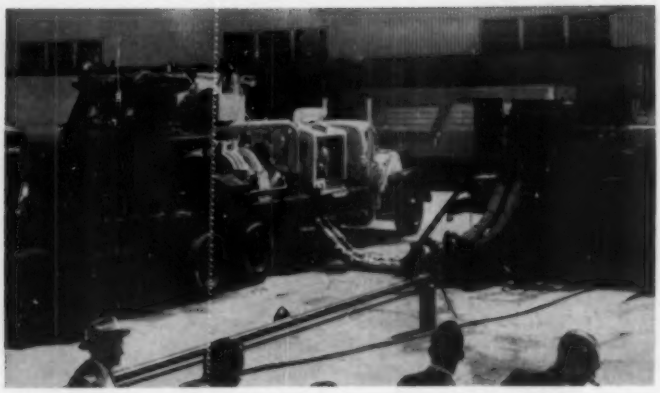
The fracturing treatments performed thus far on the two Kenneth Kiester wells, No. 12 Cobb and the No. 3 Hollingsworth, presented relatively small demands on the unit.

On the Cobb well, 18,000 gal of water and 20,000 lb of sand were pumped down casing at a maximum rate of 24 bbl per min and at a maximum pressure of 1750 psi. This job took 22 minutes.

On the Hollingsworth well, 20,000 gal of water and 20,000 lb of sand were pumped down casing at a maximum rate of 30 bbl per min and at a maximum pressure of 1750 psi. Total pumping time for the well was 17 minutes.

Field performance of the gas turbine unit supported conclusions previously reached by Halliburton engineers. When the pump rpm rate was increased from 275 to 390 rpm, volume increased by about half at the same pressure rating.

An equally-important consideration for high-pressure, high-volume fracturing treatments, quick responsiveness of engine and pump, was shown during the first two fracturing treatments. Operator on the truck was able to go from no-load to full-load in less than 10 seconds.



Western Company's Jet Fracmaster uses split-shaft turbine to provide higher horsepower with less weight.

Large chunks taken from wells during workovers include, left, cast iron production packer drilled with a 3.5-in. pump, aluminum bridging plug drilled with a 2⅞-in. pump, and on the right, a cast-iron production packer drilled with a 4.5-in. pump.

Western's Jet Fracmaster In Operation

Western Company's Jet Fracmaster 1200, weighing some 15,000 lb less than other diesel engine fracturing units with less than half the horsepower, will be placed into field test service immediately after demonstrations held at the oil show.

Three major components of the fracturing unit, which resulted from four years of developmental effort by Western, were specially engineered for this unit. Solar Aircraft Company developed the gas turbine exclusively for industrial use and specially engineered this first production model for Western.

Engine designation is Saturn T-1000, and it develops 1250 bhp. Western Gear Corporation designed and manufactured the special four-speed transmission. Pump used is Western's RB-100, a single acting, triplex, high capacity fracturing pump which is patterned after Western's RB-80, which has been in field use for several years.

A split-shaft turbine provides higher horsepower with less weight. This allows variation in the speed of the pump without affecting hp output of the engine. Split shaft provides an infinitely variable-speed fluid drive. Compressor is driven by one 750-hp shaft, and the load by the other shaft at 1250 hp. Free-turning split shaft and direct coupling also eliminates clutches.

Four-speed transmission transmits 1250 hp at 6000 rpm input from engine with four variations in output speed.

Gear unit is designed with one high-speed mesh only, providing minimum number of high-speed bearings, minimum lubrication requirements, and moderate speed for brake output.

Pump discharges a maximum of 38 bbl fluid per minute. Plungers are 6¾-in. diameters and have 10-in. stroke. Discharge pressures range to 6000 psi, and other pressures may be attained with other size plungers.

A remote control panel is used to operate the unit in the field. Automatic controls for maximum pressure with manual override will permit operating at maximum injection rate without exceeding maximum pressure.

Hammering Machine For Cleaning Tubing In Derrick

An unusual piece of equipment for cleaning oil well tubing during workovers without laying the tubing on the ground was exhibited by The Hammerhawk Corporation of Signal Hill, California.

New concept makes it possible and practical to remove scale and most wax deposits with two basic principles working together. A hammering action generated by pneumatic hammering machine in the device sets up high frequency and high amplitude physical vibration. This places a shock load on the tubing wall and breaks loose scale deposits.

Second principle then brings tubing ID to original drift diameter through the use of an especially-designed cutter gage rabbit. Gravity pulls this rabbit down through the tubing from top to bottom. Vibrations set up in the tubing by the hammering machine produces a cutting-beating action against the cutting edge of the rabbit. This rabbit finishes cutting the deposits from the inside of the tubing and also serves as a gage.

System operates by pulling hammering machine up the tubing with the sand line until it reaches the elevators. Then the derrickman places the cutter-gage rabbit into the tubing. If the gage falls through, tubing is clean. If scale obstructs the rabbit, hammering machine is started to move the rabbit through the tubing.

Wire-Line Tool Combines Sand Pump, Drilling Head

An unusual wire-line sand pump and drilling tool drills out cast iron bridge plugs and production packers, cement retainers, and other hard materials. A special valve-pump sucks up large chunks of these materials.

Introduced a couple of years ago, the Glutton Sand Pump performed some 180 jobs during 1959 and 260 jobs during the first nine months of 1960. Using tool eliminates necessity of hauling a workover rig out to the site, since servicer drives up with a swabbing unit and goes to work.

In operation, a flat-bottom shoe on the tool drills out sand, loose material or junk, using force applied by its own weight. Wire line operates plunger to draw debris through a hole in the chisel head and a trap-door valve into the body of the tool. When plunger loses travel, the chamber is full and pump is pulled to the surface. Three rotary valves on a mandrel form this plunger.

Applicable also in slim holes, pump sizes and casing sizes they are used in 1⅞-in., 2⅞-in. casing; 2⅞-in., 4½-in., 6-in. to 7-in. casing; and 5-in., 7 to 8⅝-in. casing.

Special attachments facilitate specific jobs. For removing river or frac sand, a sucker-type head attached to a sub containing a sliding door removes sand quicker. At the surface, the sliding door permits easier dumping of contents. This sub isn't used with the chisel-head for drilling because of the possibility that it would be too weak.

No fishing jobs have resulted in the 340 jobs performed. Heat-treating of the alloy steel head gives it strength and hard surfacing applied gives a strong cutting edge.

Production and Refinery Equipment Company of Odessa, Texas manufactures the Glutton Sand Pump. ★ ★ ★

HYDRAULIC UNITS SAVE WORKOVER DOLLARS

Two new all-hydraulic compact units promise big savings in workover and servicing jobs, especially in over-water completions

"IF TRANSPORTATION AND RIG-UP COSTS were cut in half, we could show a decent payout on the workover of some of our hard-to-get-to wells." This statement by a South Louisiana operator points up one of the conditions that have led to the development of two new compact, all-hydraulic workover units now in the field.

Otis Engineering Corporation, Dallas, and Brown Oil Tools, Inc., Houston, have introduced the new units designed to reduce transportation and rig-up costs as well as providing savings on workover jobs in wells with small tubing under pressure.

The growing number of small-tubing, over-water completions in the Gulf Coast and South Louisiana inland water areas is expected to give the new units most of their jobs. These workover units are especially adaptable to such work. Their small size permits them to be mounted in and work in the limited space usually available on over-water installations. All-hydraulic operation and control of both units provide precise operation of the units and positive but careful handling of the pipe.

Both of the new units are now in the field and have already proved their ability as valuable tools in the continual fight against high well servicing and workover costs.

The Otis hydraulic workover service unit is contained in two packages. The skid-mounted power package includes the engine, the hydraulic pump, and the hydraulic fluid tank. On over-water locations, the power package can be mounted on a small barge tied up at the location, or, if space permits, it can be placed on the existing platform.

The working unit, connected to the power unit through flexible steel hose, mounts entirely on the tree. This unit consists basically of a stack of three blowout preventers above which are mounted two sets of hydraulically-actuated

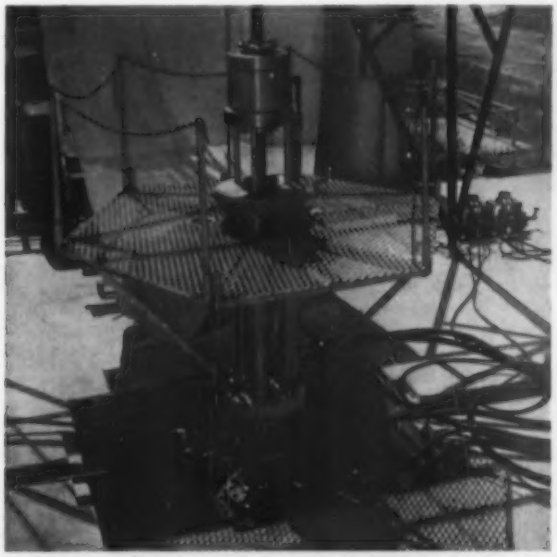
See OTIS Page B-30

Hydraulic workover unit manufactured by Otis Engineering Corporation mounts entirely on the wellhead and is powered by a separate skid-mounted power package.

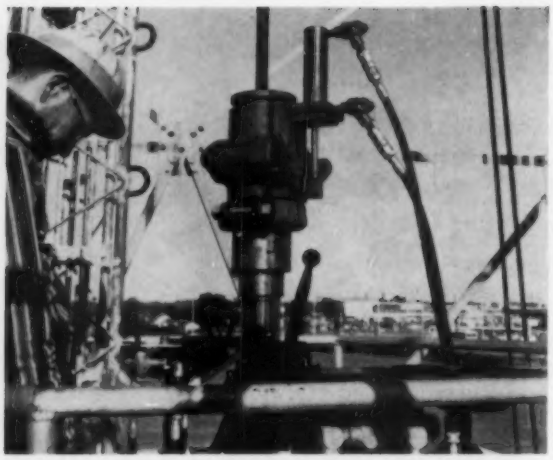
The Brown hydraulic snubber and workover unit was designed to make pulling and running pipe under pressure a more efficient operation.

All operations — lifting and lowering pipe, slip actuation, and control — are hydraulic. Two sets of opposed double-acting slips — one traveling, the other stationary — are hydraulically operated to grip the pipe for snubbing and running pipe in or out of the well. The slip controls are mechanically interlocked so that one set of slips is always engaged.

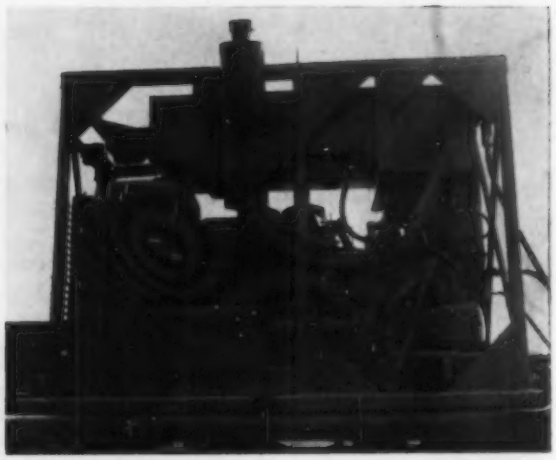
See BROWN Page B-31



Hydraulic snubber and workover unit manufactured by Brown Oil Tools, Inc., is mounted on the wellhead and delivers power to traveling slips through three hydraulic pistons.



Operator's platform mounts all controls in easy reach of the operator. Traveling slips on top of hydraulic piston pull pipe from hole or snub pipe in under pressure.



Skid-mounted power package can be loaded on truck for land operations or on barge for water operations. It is connected to workover unit through flexible hoses.

slips, one set looking up and the other looking down. A single vertical cylinder contains a double-acting piston which is topped with another set of hydraulic slips.

All operations of the unit are controlled from a simple control console located on the operator's platform. A single "joy-stick" type control regulates both direction and speed of travel of the piston.

Also mounted on the console are levers which actuate the three sets of slips. These levers are interconnected in such a manner that it is impossible to release the pipe prematurely, whether running or pulling pipe. Pressure gages on the control panel aid in operation and control of the unit.

Operating Procedure

When running tubing with well pressure sufficient to cause negative effective weight of the pipe, the traveling slips on top of the unit grip the pipe and hydraulic pressure moves the piston and pipe downward. The middle blowout preventer seals around the pipe while the stationary slips remain open. When the tubing collar reaches the preventer rams, the upper preventer is closed around the pipe above the collar and the middle preventer rams are opened, allowing the collar to pass through the preventer stack under complete control.

At the end of the down-stroke, the pipe is gripped by the upper stationary slips, the traveling slips are released and the piston moves upward to grip the pipe for another down-stroke to complete the snubbing-in cycle.

To pull light pipe, the procedure is the reverse of that outlined for running light pipe. The upper stationary slips hold the pipe in the hole against the well pressure tending to force the pipe from the hole. The traveling slips on top of the piston grip the pipe at the bottom of the stroke and allow it to be forced out of the well as the piston travels to the top of its stroke.

In wells where there is no pressure, or where the weight of the pipe in the hole is greater than the pressure force on the tubing, the bottom stationary slips are used to support the pipe. The traveling slips are reversed so that they grip the pipe at the bottom of the piston stroke and lift it to the top of the stroke.

When pulling heavy pipe from a hole under pressure, pipe collars are lubricated through the blowout preventer stack. The upper preventer is closed around the pipe and the pipe is stripped through it. When a collar reaches the closed preventer rams, the middle preventer is closed around the pipe below the collar and the upper preventer is opened to permit the collar to pass. Upper rams are then closed and middle rams are opened to lubricate through the next collar.

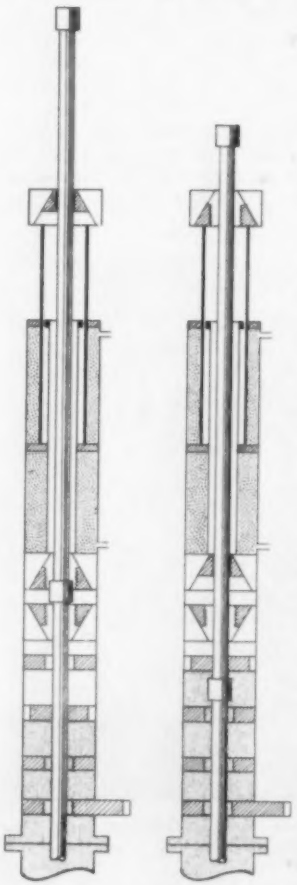
Working Features

The Otis hydraulic workover unit has been designed to run or pull macaroni tubing up to 1½-in. in diameter, inside either tubing or drill pipe. The pipe is supported along the entire length of the six-foot stroke of the unit, eliminating the danger of buckling or bending the pipe.

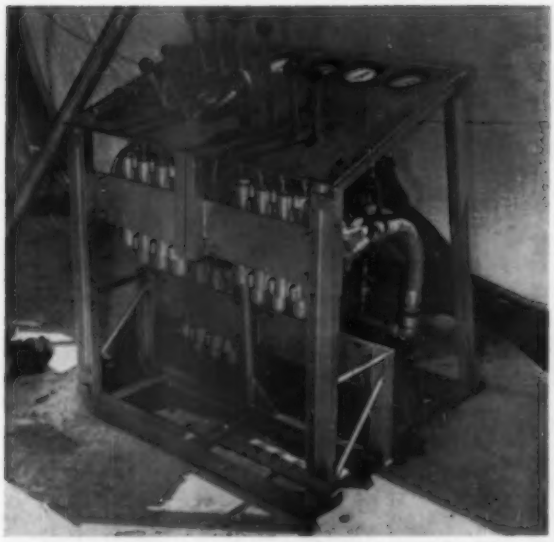
Running or pulling power can be regulated to meet the well's specifications. The unit has a standard working pressure rating of 5000 psi, and a high pressure unit is rated at 10,000 psi working pressure.

Pipe in hole can be rotated through the unit for such workover and servicing operations as fishing, drilling plugs or packers, setting or releasing pipe or packer.

The entire unit is highly portable and compact and could be easily moved by helicopter or plane. The heaviest component, the blowout preventer, weighs 1075 lb.



Operating diagram of Otis' workover unit shows procedure for snubbing in pipe under pressure, illustrates slip action and method of lubricating collar through preventers.



Control console places in one package all controls for lifting and lowering pipe, slip actuation, and blowout preventers. Gages indicate various operating conditions.

Unit at work on offshore location shows minimum of space required. On locations without platforms, barges can be used to hold control console, power package, and racked pipe.

Unit Operation

When running or pulling heavy pipe, the upward-facing slip segments of both the stationary and traveling slips are used. Pipe is held by the stationary slips while the traveling slips grip the pipe at the bottom of their downstroke to lift the pipe in pulling operations, or they grip the pipe at the top of the up-stroke to lower the pipe.

If the pipe is light (weight of pipe in hole is less than opposing pressure force), the downward-facing slip segments are used in combination to snub in the pipe against the well pressure. When running pipe with collars in a well under pressure, the operator controls the blowout preventers to permit the collars to be lubricated through the preventers.

The upper, or traveling slip bowl is rotatable in its housing, so that the pipe may be rotated with any device such as power tongs or a power swivel, or a hydraulic motor and gear drive can be attached to the unit. This allows drilling or milling operations with precise weight control because the double-acting slips in the traveling bowl can be used to support a portion of the pipe weight or apply additional weight on the tool.

Three hydraulic pistons provide the force for lifting and lowering the pipe. The stationary slips are mounted in a bowl at the top of the cylinders and connecting rods from the pistons extend to the upper traveling slip bowl.

Control and Power Packages

A separately mounted control panel is equipped with valves to control lifting and lowering, slip actuation, and hydraulic blowout preventers. Gages are provided for weight indication, hydraulic pressure, well pressure, and pressure on hydraulic preventer system.

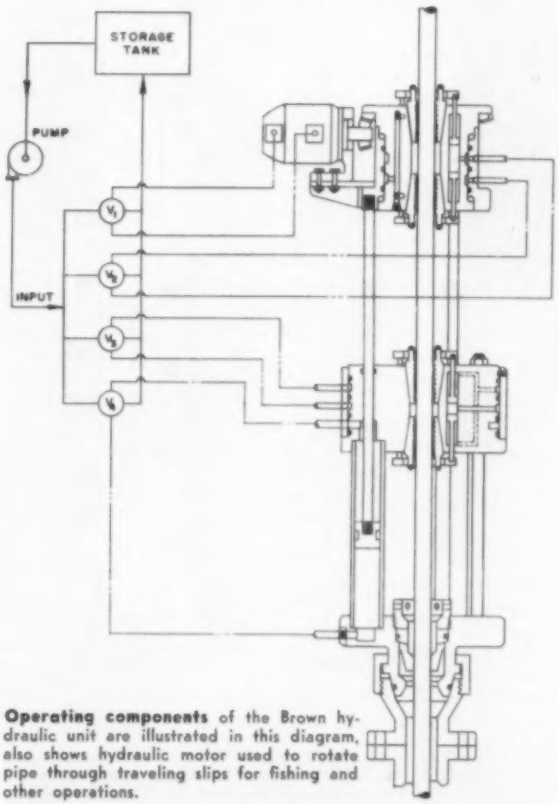
A pressure regulator can be set to limit the pull or the snubbing force on the tubing. This feature minimizes the danger of pulling stuck pipe in two and assists in lubricating pipe collars through the blowout preventers.

The skid-mounted hydraulic power unit is complete with diesel engine, fuel tank, and hydraulic fluid tank. It can be located at a distance from the well for increased safety.

The unit will handle any size pipe up to and including 2⅞-in. OD EUE tubing, and has a lifting capacity of over 10,000 ft of 2⅞-in. tubing, or the equivalent.

In field use, the unit has proved ideal for concentric string workovers, especially on offshore platforms where space is limited and moving and rigging up costs for normal workover rigs is high. On recent workovers using 1-in. pipe for concentric string workovers, the unit pulled and ran the pipe at the rate of 20 joints per hour.

The unit can also be used in pulling and running tubing in low-pressure areas where the well production may be adversely affected by killing the well. ★ ★ ★



Operating components of the Brown hydraulic unit are illustrated in this diagram, also shows hydraulic motor used to rotate pipe through traveling slips for fishing and other operations.

In field tests . . .

BOTTOM-HOLE BALL MAGAZINE

C. B. and D. E. Holt, *Pampa, Texas*

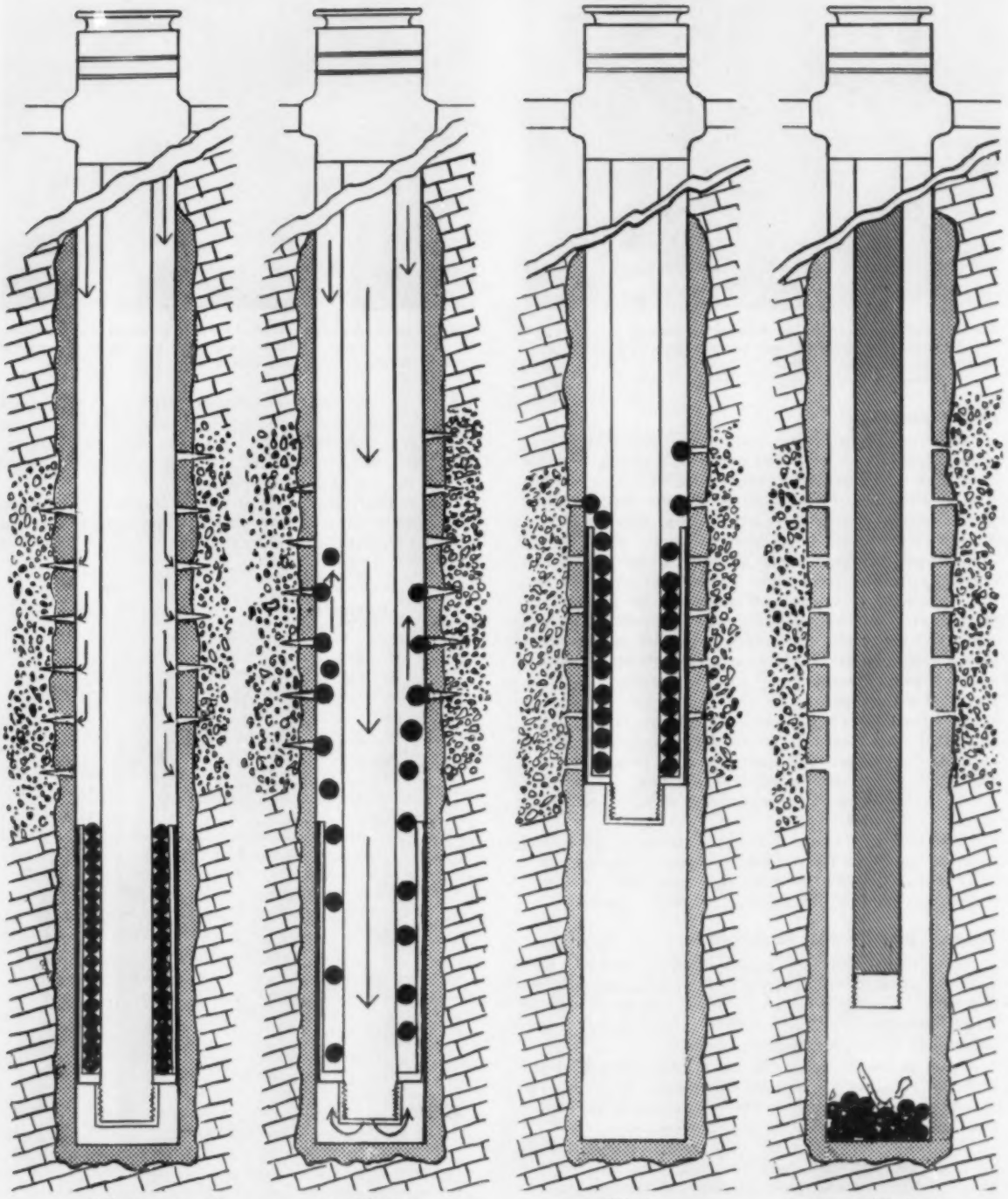


FIG. 1. FIG. 2. FIG. 3. FIG. 4.

FIG. 1. Treating fluid pumped into annular space breaks well down, opening perforations. FIG. 2. Breakdown fluid pumped down tubing flows out bottom and up through magazine. This circulates balls up to any opened perforations. FIG. 3. After treatment, pulling tubing scoops balls back into magazine for returning to surface. FIG. 4. Optional disposable magazine allows balls to fall to bottom of hole.

. . . Allows Breaking Down Formation Selectively

A BOTTOM-HOLE BALL magazine recently developed permits breaking down perforated formations a few holes at a time. Balls seal opened perforations, allowing pressure to build up and break open other formations. Repeating process opens perforations into every zone, even those with low permeability, since balls close off flow into high permeability zones.

Raising tubing with magazine attached to bottom scoops balls off perforations, allowing production to flow freely through all openings.

C. B. and D. E. Holt of Pampa, Texas, developed the tool and performed field tests which resulted in considerably increased production on several wells.

Present magazine operates in 5½-in. casing while attached to a 1½-in. stinger on 2-in. tubing.

Operation of Magazine

Bottom-hole ball magazine consists of a basket-type tool attached to the bottom of tubing and filled with the required number of ball sealers to plug each perforation.

Operator runs the magazine on tubing below the last perforation into dead fluid space. Using a pack-off type head, operator pumps treating fluid into the annular space until sufficient pressure builds up to break the well down (Fig. 1).

Then ball magazine may be put into operation by pumping as little as one bbl of breakdown fluid through tubing. As fluid leaves bottom of tubing below magazine and flows up through annulus, balls resting on bottom of magazine circulate up through annulus.

Upward flow of breakdown fluid counteracted by downward flow of treating fluids as they flow through opened perforation into formation carries balls into place as plugs (Fig. 2).

Since balls seal off all opened perforations from the bottom up, little lost circulation occurs. Extra balls fall back into the magazine, breakdown fluid stands opposite unbroken perforations, and operator recommences treatment through pumping treating fluid down the annular space to build up static head pressure.

Should balls block all perforations during treatment, pulling tubing and raising magazine scoops balls back into magazine. This eliminates the risk of surging. Then operator lowers tubing back to original position and resumes treatment.

Upon completing treatment, operator pulls tubing to scoop balls back into magazine and bring it to the surface (Fig. 3).

On wells where it may not be desirable to pull tubing, operator runs a disposable magazine. Upon completion of treatment, a chemical solution spotted around magazine completely disintegrates tool except for steel collar, thus allowing the ball sealers to fall into the rat hole. Then the operator raises the tubing for swabbing or places the well on pump (Fig. 4).

Increasing Oil Flow

Using this technique resulted in considerable increase of production from a well drilled in Brown Dolomite in the Texas Panhandle to a total depth of 3111 ft.

Operator set casing at total depth, logged the well and perforated with single shots at intervals from 2956 to 3100 ft.

After swabbing hole and bailing it dry, operator ran 2-in. EUE tubing with 160 ft of 1½-in. tubing and the magazine attached. This stinger gives balls more clearance between the tubing and casing.

Annulus contained 250 ft of water when operator set tubing and packed it off, and 30 bbl of water pumped down annulus increased static head. Acid pumped down tubing at slow rate, ½ bbl per min, spotted on formation. This slow rate kept ball from raising out of magazine prematurely.

While acid flowed down tubing, annulus kept filling as indicated by air escaping from open annulus valve at wellhead.

As annulus became nearly filled, with raw acid on the formation, the formation broke and fluid flowed into it. At the same time, air entered the open annulus valve at the wellhead.

Increasing pumping rate to 2 bbl per min down the tubing brought the balls up and plugged the hole or holes where the formation broke down first, as indicated by air escaping from open valve again.

Repeating process using four bbl of water pumped in at rate of 2 bbl per min secured eight different breaks for 14 holes, indicating that only a few holes broke through the formation each time.

Upon completing acid job, servicer pulled tubing out and swabbed acid water back, then sand-fractured well with 21,000 gal gelled water and 60,000 lb sand. Injection rate of 50 bbl per min could put 3 bbl per min through each perforation.

The well swabbed at a rate of 20 bbl per hour and now produces at a rate of 80 bbl per day on pump with the fluid level remaining at 800 ft. All surrounding wells in the field will not produce over five bbl per day and have a fluid level of about 50 ft.

Results on Gas Well

Another application yielded results on a well completed in the East Sweet gas field of Gray County, Texas. Operator set casing at a total depth of 2355 ft and perforated the well from 2240 to 2256 ft and from 2280 to 2292 ft, using two shots per ft for a total of 56 holes.

Running the magazine on 2-in. EUE tubing, servicer placed the top of the magazine at 2304 ft, using a centralizer collar on tubing above the top perforation. This prevented the tubing from bowing to one side of the casing and keeping the balls from going over the perforations.

After packing tubing off, servicer connected an acid truck to the tubing and pumped in 1000 gal of acid. Down the annulus, operator pumped 5000 gal of fracturing oil with 10,000 lb of sand.

Procedure used consisted of spotting 12 bbl of acid on formation through tubing, slowly pumping ½ bbl per min to prevent balls from rising. Then servicer pumped 10 bbl diesel oil into annulus before pumping sand oil.

After injecting 1250 gal of sand oil with 2500 lb of sand displaced at 1200 lb pressure, servicer slowed annulus pump down and pumped four bbl of acid into tubing in two minutes.

Then servicer opened fracture pump on annulus, and displaced a second 2500 lb of sand at 1450 pressure. Repeating these two stages of operation, servicer displaced a third 2500 lb of sand at 1700 lb pressure and a fourth 2500 lb at 1850 lb pressure.

With the entire 10,000 lb of sand displaced into annulus, servicer pumped diesel oil down the tubing rapidly and balled it off completely. Pressure remained fairly constant at 2600 lb, leaking off slowly with pumps shut down.

Then servicer pulled two joints of tubing, taking balls off perforations, and well lost its pressure completely.

Filling casing completely with diesel oil flushed casing. Upon completion of job, well potentialed 4,500,000 cfd — substantial production for this area.

* * *

FIELD USE OF RADIOACTIVE GAS TRACERS

F. E. ARMSTRONG
Bureau of Mines, Bartlesville, Oklahoma

Bureau of Mines has developed and tested a practical system of techniques and instrumentation for radioactive gas tracers

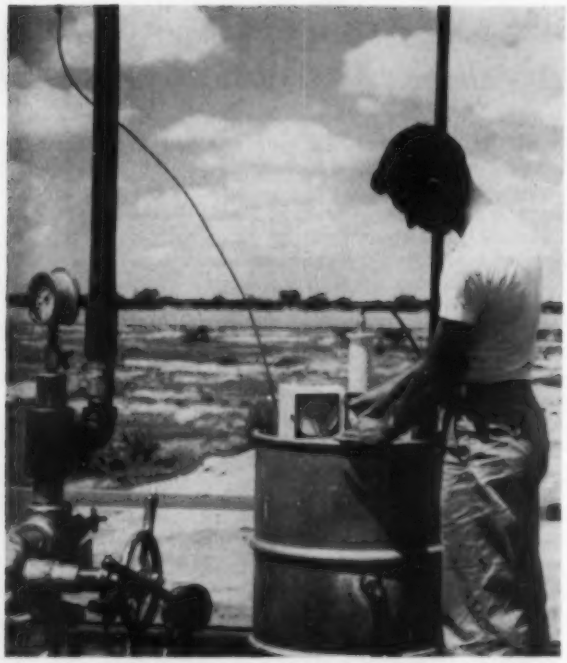


FIG. 1. **Monitoring system** developed by Bureau of Mines for detecting and measuring radioactive gas tracers is shown under test in the Spraberry Trend of West Texas.

A SIMPLE, EFFECTIVE and economical system for applying radioactive gas tracers to oilfield production problems has been developed by the Bartlesville Petroleum Research Center of the Bureau of Mines. Although the detection method is less sensitive than some laboratory methods, advantages gained from continuous recording, lack of need for continuous attendance, and much lower cost, outweigh the necessity of using larger quantities of tracer. Techniques and instruments were first tested in a pilot water flood operation in the Spraberry Trend of West Texas. The simple testing assembly is shown in Fig. 1.

Field Use of Tracers

Radioactive fluid tracers used in previously reported[1,2] oilfield applications have been predominately gamma-emitting isotopes, chosen because of the greater ease of detecting such tracers under field conditions. Two methods of detecting and measuring gamma-emitting tracers have been used by the Bureau of Mines: well-crystal, scintillation systems for quantitative sample counting and Geiger-Mueller-tube systems for continuous monitoring.

Use of radioactive tracers in gas-phase systems involves applying several principles quite different from those used in liquid systems. Of primary importance is the much lower density of gas than that of most liquids. In liquids, average range of even the most energetic beta particles is only a fraction of an inch. In gas these particles may range several feet before being absorbed. Thus, while use of beta-emitting isotopes as tracers in liquid systems is not practical because of self absorption within the active fluid, this problem does not exist in gas systems, at least within practical pressure ranges.

It is fortunate that this situation does exist, as few gamma-emitting radioisotopes are available that can be compounded into materials that are stable gases at normal temperatures and pressures. The inert nature of krypton and xenon assures that no loss of tracer will occur as a result of chemical reactions during the tracer process. Of the readily available and applicable isotopes of these two elements, krypton-85 has the advantage of lower cost, higher energy beta emission (0.695 Mev as compared to 0.345 Mev for xenon-133), and lower mass number, more nearly that of natural gas. The shorter half-life of xenon-133 (5.27 days compared to 10.27 years for krypton-85) gives it an advantage for some specific applications.

Krypton-85 was chosen for the tracer to be used with the instrumentation described in this article. Factors involved in this choice were the need for an inert gas, an experiment of probable long duration, and the desirability of high beta energies to simplify counting techniques. Properties of krypton-85 meet these requirements.

Another advantage in using beta-emitting tracers, particularly the inert gases, is the relatively low hazard associated with their use. In addition to expected negligible loss of tracer because of adsorption or ion exchange, calculations showed that loss of krypton by solution, under normal reservoir conditions in the Spraberry Trend field test, should be less than one percent.

Conditions of Tracer Test

Results of earlier field tests of radioactive-gas tracers to determine the distribution of cycled gas, using tritium, tritiated methane, and krypton-85, were reported by Welge.[3] However, in tests made to evaluate the techniques and instruments described here, conditions were quite different from those reported by Welge.

Engineers of the operating company wanted to tag with radioactive tracer all gas to be injected over a given period. Because the tracer was to be injected into the lower of two productive formations, the tracer gas had to be produced through the oil and water coming from the upper formation. To avoid the excessive time required and the inherent unreliability of sampling and laboratory analysis, it was decided

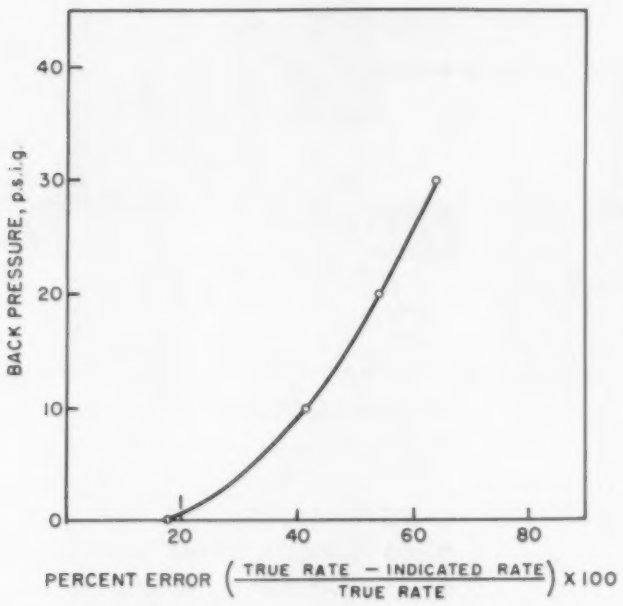


FIG. 2. **Operation of purge-meter** used to inject gaseous radioactive tracer into gas stream resulted in small positive error in injection rate as a function of varying backpressure.

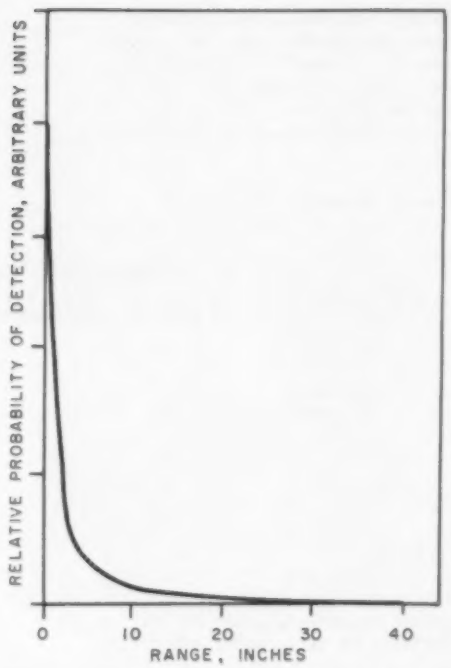


FIG. 3. **Effective range** of Krypton-85 Beta particles shows that extending sample volume to detectable range greater than 10 in. results in only a small increase in counting rate.

to record continuously, at as many as nine widely separated locations, radioactivity of gas injected and produced, and to check intermittently the radioactivity of gas at four other more distant locations.

Transit time for the gas was predicted to be several weeks or a few months. It was believed that some useful information might result from analyzing data obtained on transit time, dilution, and shape of the curve describing the increase of tracer concentration during its initial appearance at a production well. However, the most significant and useful information expected was the identity of the wells at which tracer appeared because of the predicted directional permeability of the oil-productive formation. Consequently, measurement of absolute radioactivity levels was not of great importance in the test.

The pilot gas-injection plant consisted of two 2-stage compressors in series compressing natural gas from a line pressure of about 25 psig to an intermediate pressure of 450 psig and a final injection pressure of about 1000 psig. Although tracer might have been injected at any of the three stages, the suction line to the first stage was the most suitable. However, variation in line pressure at this point was objectionable. Contamination of compressors was not a major consideration because of the inert nature of tracer gas.

Tracer Injection Technique

At least one comprehensive investigation of the problem of gas proportioning was known to be in progress.[4] However, results were not available, and a reliable proportioning system was needed within a short time. As the assumption of a reasonably constant gas flow had been made, the problem thus was simplified to one of maintaining a constant, low flow rate into a line with a slightly varying back pressure. Pressure in the compressor suction line varied between 20 and 30 psig.

The practical detection limit for apparatus used in this study was established at about 10^{-6} curies of krypton-85 per cu ft of natural gas. One curie of carrier-free krypton-85 is less than one cc of gas at standard temperature and pressure. An arbitrary "tag" level of 20 to 30 times the detection limit was chosen to assure reasonable reliability of detection and measurement at the production wells. The krypton-85 was easily obtainable in weekly shipments. From evaluation of all these parameters, it was decided to inject one curie of krypton-85 weekly. With a normal injection rate of 3.5 million cu ft of natural gas during this period, tag level thus was established at 28 times minimum detectability.

The tracer gas initially was diluted with 200 cu ft of natural gas in steel, high pressure cylinders to facilitate proportioning of one cc of gas into the flow stream over a period of one week. Cylinder pressure of 1800 psig was reduced to 40 psig with a two-stage pressure regulator, and the gas at this pressure was fed to a purge-meter regulator unit.

This unit consists of a rotameter for measuring gas flow and a needle valve for controlling the flow. The needle-valve assembly is equipped with a differential-pressure regulator which provides a constant pressure drop across the valve. It was hoped that a constant flow rate would be obtained, dependent upon the valve setting and independent of upstream or downstream pressure variations. Unfortunately, laboratory tests of the assembly yielded different results (Fig. 2). However, since resultant error was positive rather than negative (flow rate increased instead of decreased with an increase in downstream pressure), the net effect was to correct to some degree for the increase in compressor input rate caused by an increase in compressor suction pressure.

Radioactivity of injection gas was monitored at a tap in the high-pressure line between the compressors and injection well. The recorder for this monitor was mounted on a panel with the flow-rate control instrument in a doghouse at the compressor site. This arrangement provided a quick check upon the effects of varying the injection rate. The reset time (time elapsed

between the moment of a change in tracer gas-injection rate and appearance of a change in recorder reading) was about 1½ minutes, most of which was the delay caused by the rate of sample changing in the monitor chamber.

Tracer Detection Technique

Previously reported methods of detecting gas tracers used in oilfield operations[5,6] in general involve taking samples in the field with subsequent laboratory analysis. There are several appropriate methods of laboratory analysis. Most of them involve purifying the gas, transfer to a proportional counter or an ionization chamber, and analysis of the prepared sample by routine radioassay techniques.

An obvious improvement of these techniques is to develop automatic devices to handle the entire procedure of taking and analyzing samples at predetermined intervals in the field. Such a device must be complex and subject to extreme field maintenance problems. Of even greater importance, the cost of such a system is very high.

There are two basic approaches to the problem of detecting very small concentrations of beta-emitting radioactive materials. The first is to increase the sensitivity of the detecting device to the point where every radioactive disintegration taking place in the sample is detected. This type of instrument is exemplified by the proportional counter and the liquid-scintillation counter. However, these instruments have an inherent small sample capacity because the sample must be entirely contained within the sensitive chamber volume.

The second approach, and the one applied in developing the detection equipment herein described, is to use detectors of moderate sensitivity to monitor relatively large sample volumes. Where a virtually unlimited amount of sample exists, this is the more practical approach.

Fig. 3 shows that, although the maximum range of beta particles from krypton-85 in air is nearly 80 in., the range of diminishing return (range beyond which further extending counting-sample dimension out to infinite sample volume would increase the actual counting rate only a few percent) is less than 10 in. There are several reasons for this. First, the average energy of the krypton-85 beta particle is about 0.240 Mev, which corresponds to an air range of approximately 28 in. Second, commercial, thin-wall, G-M tubes have equivalent wall densities of about 30 mg per cm². This introduces an attenuation factor equivalent to 10 or 12 in. of air. Finally, the application of the inverse-square law reduces the effective counting-volume radius to between five and ten inches.

From these observations it appears that a suitable sample chamber for counting krypton-85 in methane at atmospheric pressure, using a thin-wall, beta-sensitive G-M tube, would be spherical and about 20 in. in diam. Steel drums of 55-gal capacity are about 19 in. in diam and 30 in. high. They are cheap and obtainable with a zinc coating to prevent corrosion. Although the volume is somewhat greater than desired, the sample available in this application was essentially unlimited.

The recording count-rate meters used with the counting system have been previously described.[7] The G-M tube used was a Victoreen 1B85 beta-gamma tube, which had an aluminum cathode with a density of 30 mg per cm². These tubes cost less than $10 each. Each tube was mounted on the end of a short support which placed it approximately in the center of the counting chamber.

A diagram of the installed counting equipment is shown in Fig. 4. A self-starting siphon in the bottom of the drum maintained a liquid seal and also prevented the drum from filling with condensable fluids. Sample gas was vented to the atmosphere through a short tube which extended to the lower portion of the drum.

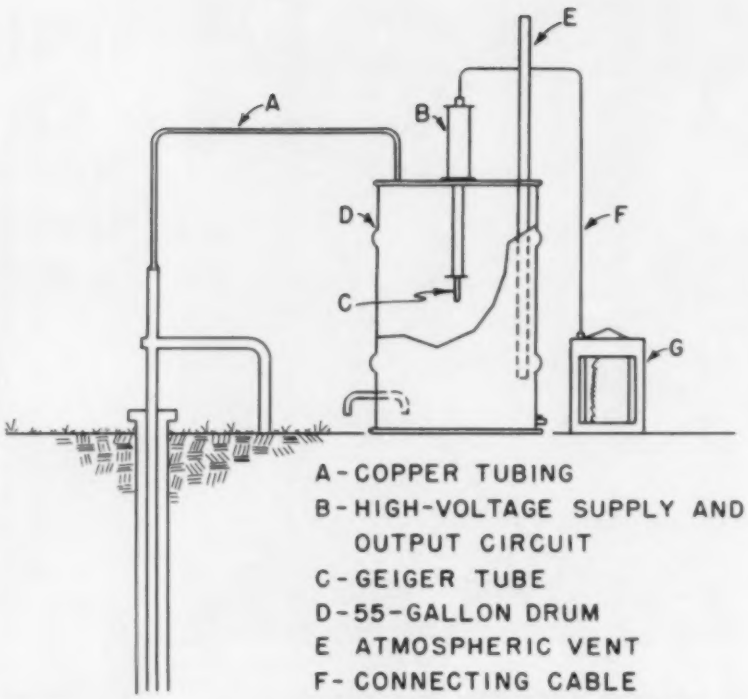


FIG. 4. **Monitoring system features Geiger tube mounted in a 55-gal steel drum.**

Background counting rate of the unit was about 50 counts per minute. Sensitivity of the system to gamma radiation was very low, and the drum walls were sufficiently heavy to prevent passage of any beta particles. Consequently, variations in background level that might have been caused by fallout, radon buildup at the earth's surface, or other nuclear phenomena, were insignificant. Some variation in background level from well to well could be attributed to varying amounts of radon in the produced gas. More precise measurements than those obtainable with the recording rate meters were made with a portable, battery-operated scaler.[8]

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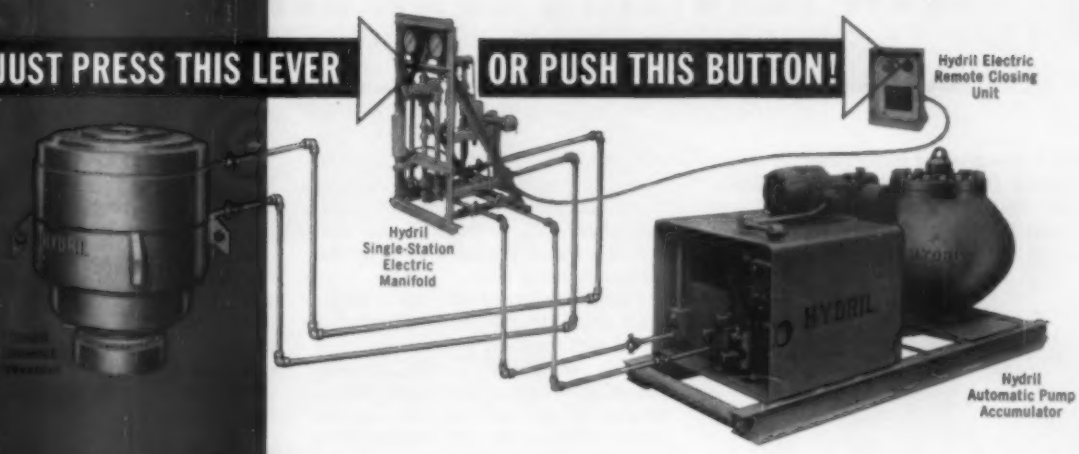
★ ★ ★

To STOP a blowout

JUST PRESS THIS LEVER **OR PUSH THIS BUTTON!**



THE HYDRIL ENGINEERED

BLOWOUT PREVENTION SYSTEM

You're looking at the most complete and flexible combination of equipment ever offered to control menacing downhole pressures. The Hydril Control Manifold—with hydraulic or electric remote operators—triggers the system from driller's and remote positions, drawing from the Hydril Automatic Pump Accumulator, a self-replenishing powerplant, the power to close the Hydril Blowout Preventer and auxiliary control equipment. This safety system enables all drilling to proceed in confidence that dangerous well pressures are under positive control.

Flexibility of the system enables the operator to choose from a wide range of sizes, types and capacities of Hydril Blowout Preventers, Automatic Pump Accumulators, and Control Manifolds. Accumulators are available for electric or gasoline-engine operation. The Accumulator and control devices can be located at a safe distance from the well, with additional controls, of course, within the driller's reach.

Let your Hydril representative show you how the Hydril Safety System is tailored to fit your well conditions...and how

HYDRIL TAKES THE BLOW OUT OF BLOWOUTS!

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A SAFETY PROGRAM . . .

More profits for the well servicing contractor

BARRY TURNER, *Safety Director, Chris Well Servicing Co., Ltd., Oklahoma City, Oklahoma*

A well-organized safety program means health for the employee, fewer losses for the insurance carrier, and lower costs for the contractor

INSURANCE PREMIUMS are the second highest cost of doing business for a well servicing contractor—running from 10% to 13% of the total payroll—a cost exceeded only by the company's labor costs.

These high premiums are a direct result of the poor experience record of the oil well servicing industry.

Chris Well Servicing Company, Ltd. made its decision to enter into a program of accident prevention on the sound business basis of holding down these insurance costs, coupled with the desire of management to avoid, to the greatest extent possible, any injuries to company personnel.

Entering into a full scale safety program is a step which most well servicing companies would have to weigh with great gravity. Our company was no exception. The program had to hold in advance the promise of paying for itself, and the problems of such a program have deterred a number of companies from attempting it. In the final analysis, it was decided that a real safety program tailored for a well servicing company had every opportunity to prove successful, both from the standpoint of preventing accidents and injury and from the standpoint of the balance sheet.

Major Problems of Safety Programs

There are five problems of major importance which must be met in initiating and effecting a safety program for a well servicing company:

Cost of the program. This includes the salary of the safety director, auto

This battered hard hat saved a man's life. Chris Well employee, John Mullens, who was wearing the helmet, got off with nothing more serious than a stiff neck.

Safety Director Barry Turner stays in close touch with field operations at all times. Mobility is at a high premium in administering a safety program for a well servicing contractor.

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To Garrett Oil Tools' outstanding research and development staff, modern manufacturing facilities and world-wide sales and service has been added new engineering talent, volume production equipment and an expanded service organization.

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and other travel expense, office upkeep and materials, secretarial time, time lost during safety meetings, publications, expense of dinners and special meetings, and audio-visual equipment, photographic supplies and film. Many well servicing companies, of course, are not big enough to pay the cost of providing a full time safety engineer. Fortunately for Chris, it was possible to embark from the very first on a program which includes a full time man.

Rapid turnover of personnel. This is an extremely important factor in setting up a safety program for a well servicing company. Hourly pay, rapid moves, short jobs and the cyclical nature of the well servicing business necessarily make long tenure the exception rather than the rule. Safety must be sold to the personnel of a well servicing contractor within an exceptionally short space of time.

Tradition. Oldtimers in the business are no more than human in that they have a natural reluctance to change their way of operating. This is coupled with a certain amount of reservation for the opinions of staff personnel. The idea so often expressed is, "We've done it this way for so many years, why should we change now?"

Shortage of management time. Pressures on management of oil well servicing contractors are numerous and quite often management feels there is not sufficient time to accept the responsibility to push through such a program.

Necessity not clearly visible. Many companies are unaware of their own need for a safety program. They know that their premiums are high but they have not taken time to analyze the sole cause—a poor accident record.

A planned program of safety is designed to overcome each of these problems.

Cost of the program is the first objection. In viewing costs in their proper perspective, however, we must consider the potential profits to be realized through our original investment.

The expense record of the entire industry has resulted in high rates for all well servicing contractors. The experience of the individual company establishes its rates, and these are expressed in relationship to the industry average. Early establishment of an improved experience record offers an excellent opportunity for a substantial increase in profits, through reduced costs.

As for the problem caused by the turnover of personnel, this is a real problem with no built-in solution. It is a problem which remains with a safety director throughout the administration of his program. This problem is the basic difference between a well servicing company's program and safety as practiced by companies with more or less fixed labor supplies. Accelerated action and more complete information on personnel serve to counteract the turnover problem.

Personal contact with personnel is vital to the success of any safety program. Here, Safety Director Turner conducts an on-location safety meeting at one of Chris Well's rigs.

Group safety meetings are essential to a close spirit of cooperation. Attendance at this meeting included just about every man who was not actually on tour at the time.

We are confident that some reduction in turnover has resulted from the Chris Well safety program, since it has brought about an improvement in morale. Our employees feel that the company is showing a definite concern for their welfare through this program and their appreciation is reflected through their attitude toward the company and through their improved performance.

During the continuing turnover, files of information can be used for effective hiring. We are using detailed application forms. Through our systematic medical checkup prior to employment, we have erected a wall of protection against professional compensation collectors. These are the people who run up the industry rates, and, worse yet, are capable of running up your rates. Information from applications helps you spot them, and physical examinations prevent them from filing suit against you for an injury not sustained while in your employ.

The emotional or prejudiced objection to the program — "We've never done it before"—cries forth in support of tradition, but tradition in this case is an expensive luxury. Of course, a safety program is not an operational necessity from the standpoint of servicing a well—but a man injured on the job is a very real obstacle to the successful and profitable completion of the job. The cost of one accident may very well wipe out all of the profit in any one or perhaps a number of jobs.

If a contractor is to continue to survive, he must be acutely aware of costs

WHAT MAKES A good waterflood Packer?

Waterflood service demands a packer that's long on performance and short on cost. The picture shows one that is. It is lean and clean, short and compact. Its packoff is positive and dependable, it has great holding power, it is easy to set and retrieve. What makes all these things possible in a low cost packer? See the facts below.

BAKER

Model A Retrievable Tension Packer

BAKER

To get Bulletin 334, write
Baker Oil Tools, Inc.,
P. O. Box 2274,
Terminal Annex,
Los Angeles 54, Calif.

BAKER OIL TOOLS, INC. / *HOUSTON / LOS ANGELES / NEW YORK*

A quick look at the facts about this important retrievable pressuring tool

WHY IT WORKS SO WELL

A Baker Model A Retrievable Tension Packer is compact (and economical) because it is simple. Baker rocker type slips, for instance, have both simplicity and superior holding power – a good combination in any pressuring tool. They are one of the great advances in slip design in recent years. This packer also has a performance-proved packing element – and a full bore that permits running wire line tools or instruments.

WHERE AND HOW TO USE IT

1 It gets its main play in waterflooding.

2 It's also a squeeze packer for simple pressuring operations where you don't need the supervision of a Baker tool specialist. For instance: when fracturing in shallow or low-fluid-level wells.

3 There are times when you may want to leave a packer in the well after a pressuring operation. The low cost of a Baker Model A recommends it for such service.

4 There are also times when you may *have* to leave a packer in the well. For instance, when you've got defective casing and there's doubt you would be able to retrieve *any* packer. You can leave one of these low cost packers in the well and knock it down out of the way with little trouble or expense.

5 You can set and reset any number of times in one trip. It is rugged enough to be used many times in many wells.

6 It is simple to maintain and redress. Standard parts are available from Baker's many field service locations.

HOW TO SET AND RELEASE IT

A simple and reliable J-Slot makes this packer very easy to set and release.

1 To set packer, you rotate tubing ¼ turn to left to unjay the slips, then apply tension to pack off.

2 To release, you relax tubing tension to relax packing element and permit slips to retract, then rotate ¼ turn to right to lock them in retracted position. Now you can retrieve.

3 There are two safety release systems.

and the reduction of accidents is one of the most apparent methods by which costs may be reduced, for reduced premiums are readily apparent in increased profits.

Management time is a vital consideration. It is the responsibility of management to find the time and means to reduce costs, thereby increasing profits. In the light of this primary responsibility, expenditure of management time to realize substantial savings is well justified.

The case in which the necessity for a safety program is not clearly visible quite often results from the failure of management to analyze carefully the accident record of each supervisor or, in this case, each rig or unit pusher. An accident is an expense, just like pipe, fuel, or payroll. The company should know what each superintendent is spending for accidents — these are a part of this man's losses or costs and should be a key component of his record.

Application of Program

The adoption by Chris of a 3-year retrospective plan for compensation insurance made company management acutely aware of the need for a positive plan to reduce the number and severity of accidents. In adopting this type of insurance, Chris was in a position to realize directly any savings through reduction in accidents, since in actuality the company is self-insured and pays the carrier to administer the program. Conversely, a sharp increase in accident frequency could be disastrous.

Immediately after the hiring of a safety engineer, a meeting was called to introduce the management group to the new safety director and his program. Management put its full endorsement behind the program and demanded complete cooperation of all personnel.

Procedures were established for safety meetings and inspections. Hiring procedures were revamped and necessary steps for selective employment were instituted. An incentive program was introduced, providing safety awards on both individual and group basis. A plaque is awarded to each unit which is successful in eliminating lost time accidents for a period of six months. Individual awards are given for each year without a lost time accident. These plaques and individual awards will be presented at a series of safety dinners for men of the winning units and their wives. Weekly safety meetings have been initiated and systematic safety inspection and accident investigation procedures have been installed.

The reaction has been 100% acceptance by supervisors and employees, and we have heard many expressions to indicate that the program is warmly welcomed. Most of the younger men working on our rigs come from oil field families, well aware of the impact that injuries have, and the resulting loss of income and health. They have lived with it—it's real to them.

Knowledge of equipment and techniques for fire safety is vital. There was a large turnout of Chris personnel for this fire safety demonstration.

Personal contact is important to our safety program, as it is to any safety program. The key to the program's success is the wholehearted support of the pushers and drillers—the front-line supervisors. They must be continually sold on the importance of safety and they must realize that their safety record is an important factor in rating their overall performance when they are under consideration for salary increases and promotions. Contacts are established by inspections of the rigs and discussions of safety with men on the job. Suggestions for safe working procedures are solicited from the men. This is something we have in common with the safety program of a major company; the human element is important.

Unlike a major, we are faced with the lack of continuity in our program, which results from short-term employees. It is difficult to discourage them from violating safe working rules.

To tailor our program to these conditions, we accelerate the speed with which action is taken. Immediate investigation of an accident is very important, because some of our employees are here today and gone tomorrow. Results of investigations must be sent immediately to the operations superintendent for his review, and ways to prevent future accidents of this nature are discussed at the first opportunity.

We have become very sensitive to the human factor that carries potential accidents. It has been necessary to terminate some accident-prone employees through a screening process. We have set up records on card files giving full information on present employees, to prevent our rehiring accident-prone workers by any of our offices.

The one man of our safety department must be in many places at once. His main goal is to be in the field, but there can be no neglecting his office work. The highest premium for the safety director of a well servicing contractor is to be skilled at managing his time. No staff help is available, as with larger companies. You must avoid lost circulation.

We feel that our safety contest and awards dinners are successful in awakening the interest of the men.

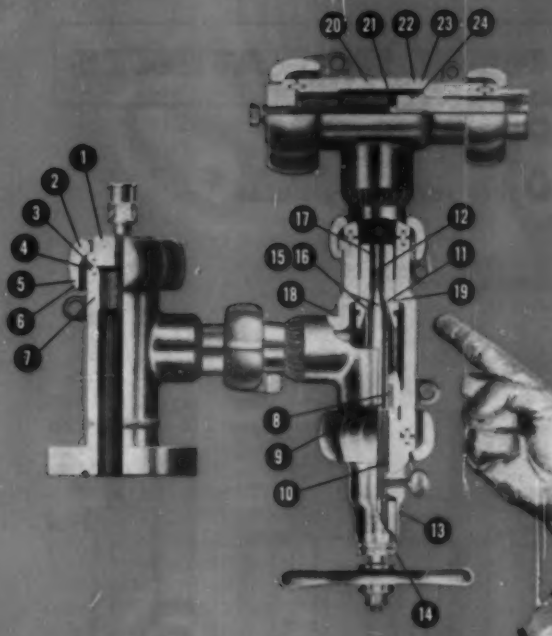
Although many of our hourly employees work only from job to job, we feel that our safety program is a key factor in strengthening their desire to become permanent Chris employees. We have even heard some expressions of regret for being injured and eliminating the opportunity for others of a control unit to receive a safety award.

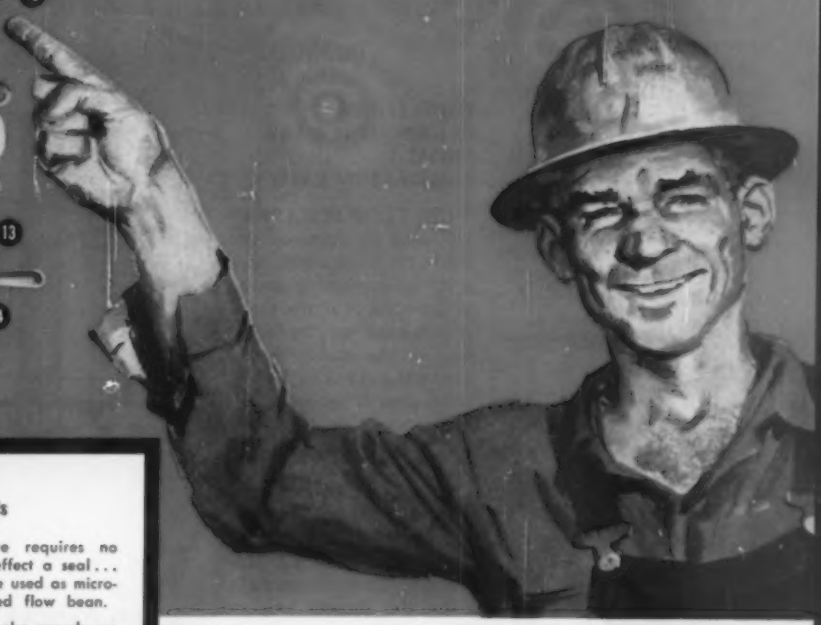
Success of our program becomes apparent in attitudes. The men have even begun freely discussing their previous injuries and means of avoiding similar accidents. This builds up resistance to future accidents, and this attitude is money in the bank for us.

Acceptance of our safety program by our employees has resulted in a 22% reduction in lost time injuries during the first five months of the program.

There are two powerful reasons — moral and financial—for carrying on a safety program. It is a splendid opportunity through which everyone involved reaps a profit: health for the employee, fewer losses for the insurance carrier, and lower costs for the well servicing contractor. ★ ★ ★

See how much more you get with a UNIBOLT Christmas tree flow manifold

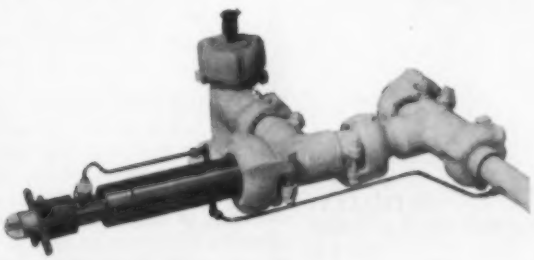




These are the "Extras" that make UNIBOLT the best buy of all manifolds

1. Tee cannot be accidentally opened.
2. No exposed threads . . . no accidental damage.
3. Concealed seat in groove . . . no accidental damage.
4. All metal seat . . . not affected by high or low temperature.
5. Lubricators, bottom hole pressure adapters, and valves easily attached to Unibolt connection.
6. 2"—3000 lb. wp Unibolt 28% stronger than 2" — ser. 900 flange.
7. Unibolt stronger than tubing threads . . . ideal for working trees with welded lift nipple. Tubing threads in tee if desired.
8. Stem packing needs no tightening.
9. Stem turns freely under high pressures.
10. Threads on stem not exposed to external or internal damage.
11. Full 2½" pilot for true stem alignment and rigidity.
12. Streamlined flow — no obstructions . . . no turbulence.
13. Wing Valve requires no grease to effect a seal . . . may also be used as micrometer-gauged flow bean.
14. Variable choke speeds up initial clean-up or running initial flow tests . . . saves rig time.
15. Nitride hardened stem and stem seat . . . resists corrosion.
16. Choice of hard chrome plated or "SA" stainless stems and seats.
17. Unrestricted 1" opening in Wing Valve will pass 10,000 bbls. of fluid per day with 100 lbs. pressure drop.
18. Wing Valve can be completely overhauled without removal from tree.
19. Wing Valve stem seat sealed by power threads and metal gasket assure alignment.
20. Positive Choke Body takes regular or "X" Beans . . . all beans flow-rated.
21. Shaped entrance on beans prevents paraffin clogging.
22. Positive Choke Body may be replaced with inexpensive tee and cage nipple.
23. Positive Choke Body can be converted to Adjustable Wing Valve by substituting two parts.
24. Beans and stem seats have external hex for wrenching.

In addition to these distinctive features, the UNIBOLT Flow Manifold eliminates impingement of flow and negative pressure areas. It may be salvaged completely or as separate units. The three separate units provide flexibility in arrangement of connections. All parts are easily replaced in the field . . . all parts are interchangeable.



The valve in this manfold is the new UNIBOLT Pressurematic Valve which is a combination automatic high-low safety valve and manually-operated wing valve for choke changing.

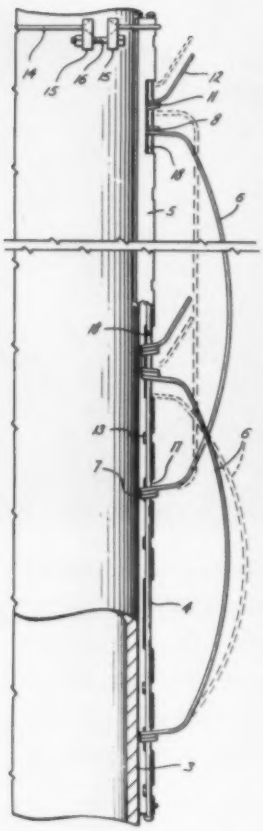
THORNHILL CRAVER CO.

P. O. Box 1184, Houston, Texas

WHAT'S NEW IN PATENTS

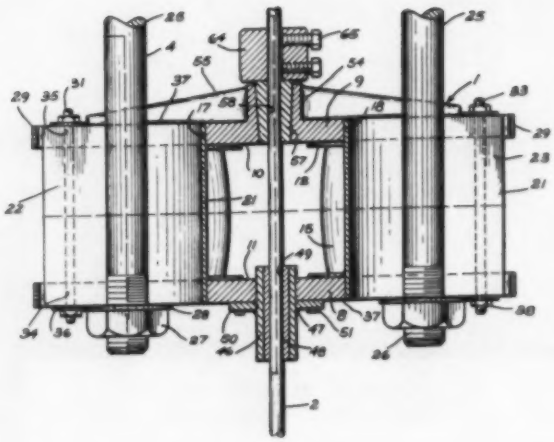
Brief notes on selected oil field patents recently granted

PAUL H. JOHNSON • JAMES R. HEAD
Patent Attorneys, Tulsa, Oklahoma



WIRE LOOPS CLEAN MUD CAKE FROM FORMATION FACE

WIRE LOOP SCRAPERS are used to remove the mud cake from a well bore prior to cementing casing in the hole. A pintle pin 4 is mounted on the outer wall of the casing 3 and supports outwardly bowed wire scraper elements 6. Both ends of the cutter elements are wrapped about the vertical pintle pin to provide a pivotal mounting. An additional coil 11 forms an integral lever arm extension 12 upwardly and outwardly from the pivotal axis of the pin. This extension is designed to control the position of the cutter element during lowering or raising operations until it is desired to scrape mud cake off the well wall. **Rotary Well Bore Cleaner,** G. T. Alexander, Jr. and Leroy Q. Gresham, Patent No. 2,945,540.

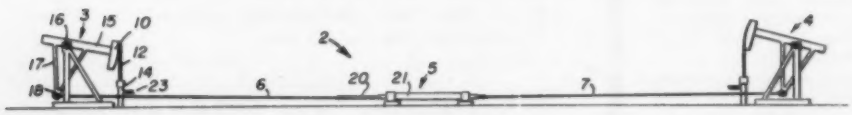


ROD HANGER ABSORBS PUMPING SHOCKS

A POLISHED ROD SHOCK ABSORBER provides supports or guides for the polish rod to minimize the damage caused by shocks or vibration. Hanger rods 25 are attached to a bottom plate 8. A compressible material 22 is between this plate and an upper plate 9 which carries the load of the sucker rods through the rod clamp 64. A bearing member 48 is positioned to support the polish rod 2 to the lower plate 8 and a guide bushing 57 supports the upper portion of the rod to upper plate 9. Shock loads developed in the sucker rod string are then absorbed in the compressible material between the two plates. **Polish Rod Shock Absorber,** C. B. McAllister, Patent No. 2,925,266.

SMALL UNIT PUMPS MUTUALLY COUNTERBALANCED WELLS

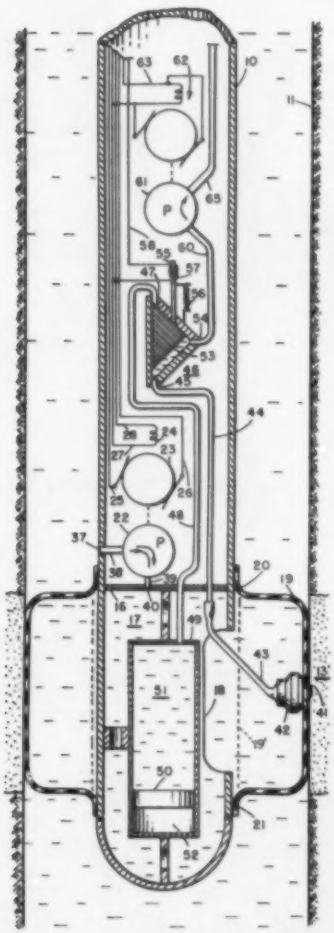
TWO WALKING BEAM pumping units can be operated from a single power source through a system described in this patent. The two pumping units 3 and 4 are placed with the horseheads facing and in line with each other. The power unit 5 supplies reciprocal motion through cables 6 and 7 to actuate the units. A hydraulic actuating system control means is disclosed in the invention. Due to the positioning of the wells and the means by which they are interconnected, each well serves as a counterbalance for the other well. **Well Pumping System,** Robert F. Gilchrist, Patent No. 2,942,554.

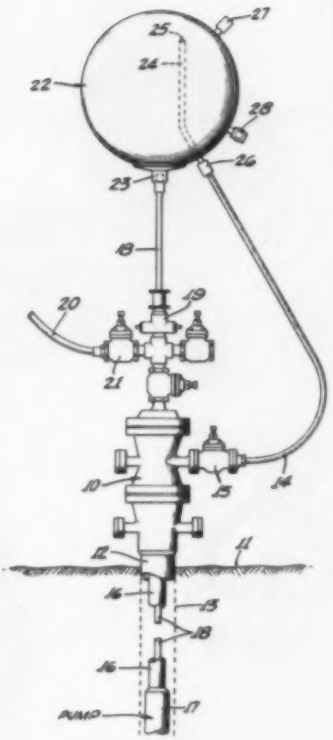


Want a copy of these patents to study the details? Write to the Commissioner of Patents, United States Patent Office, Washington, D. C. Price is 25 cents for each copy.

DOWNHOLE TOOL ANALYZES FORMATION FLUIDS

FORMATION FLUID SAMPLES can be taken and analyzed radioactively with this downhole tool. The tool is positioned in the hole with an inflatable bladder 19 opposite the formation 13 to be tested. A small pump 22 inflates the bladder with well fluid, forcing the mouth 41 of a sampling tube 43 against the formation. Another small pump 61 draws a portion of formation fluid into the testing chamber 46 where it is analyzed radioactively. The sample can then be transferred to a sample pot 51 for further analysis at the surface when the tool is withdrawn. Or the sample can be expelled from the testing chamber and the tool set at another formation for other tests. **Method and Apparatus for Analyzing Earth Formations,** J. T. Dewan, Patent No. 2,926,259.



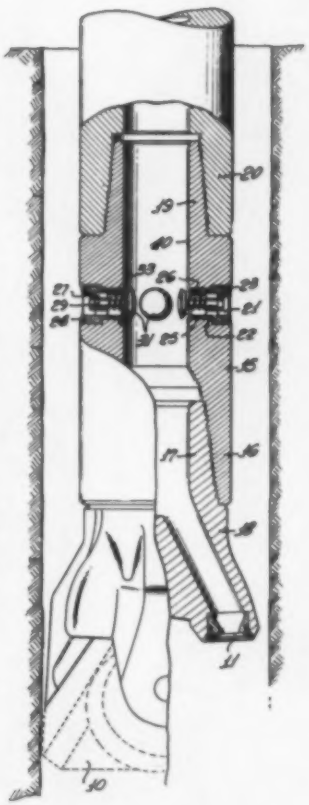


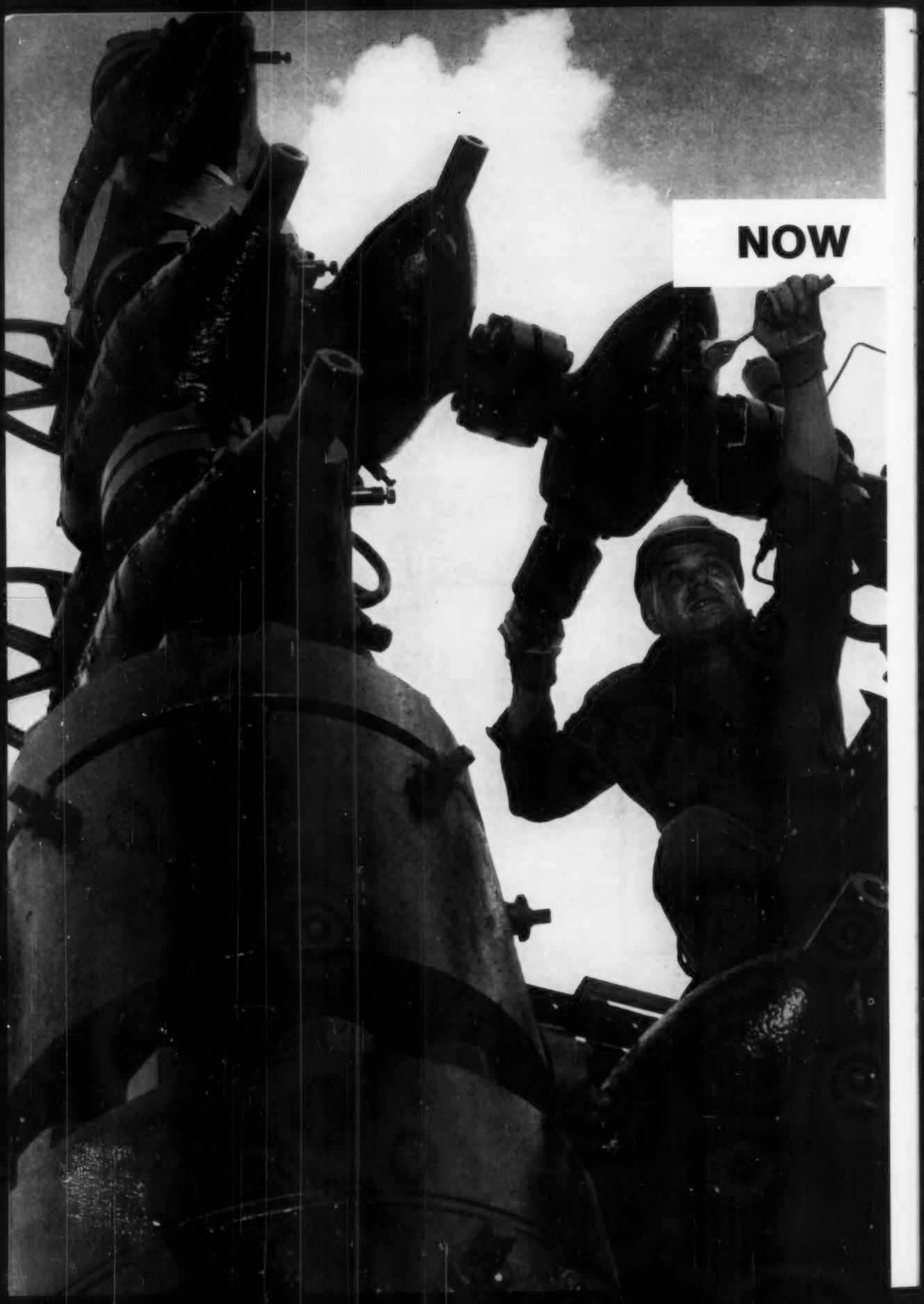
BUOYANT BALLOON PUMPS UNDERWATER WELL

BUOYANT FORCES working on a submerged body provide the force to pump a well completed under water. The submerged buoyant body 22 is attached to a sucker rod string 18 which extends into the well. Sea water in the buoyant member is expelled and replaced with gas under pressure from the well through a flexible connection 14. This causes the buoy to rise, giving the upstroke of the pumping cycle. Gas is then expelled and replaced with sea water, allowing the sucker rod string to fall in the down-stroke. **Method and Apparatus for Pumping Oil Wells in an Underwater Location,** David C. Kofahl, Patent No. 2,935,024.

BY-PASS VALVES QUICKLY DRAIN DRILL PIPE

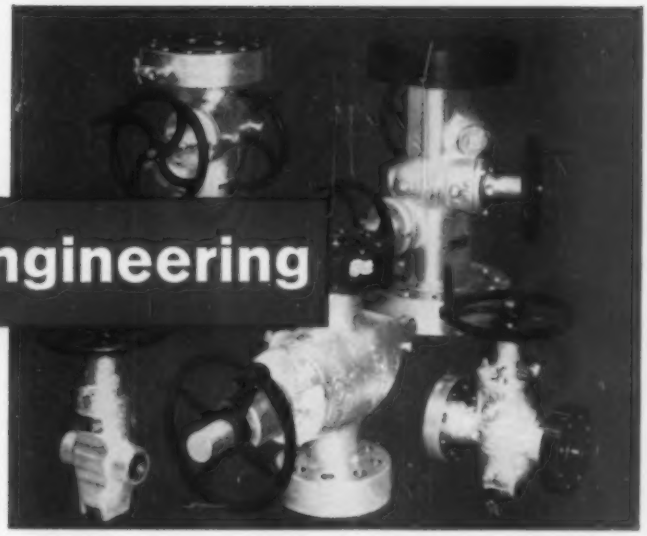
DRAINING MUD from the drill stem when using a small orifice jet bit can often be a slow process, but this invention overcomes the problem. A number of spring-loaded check valves 29 located immediately above the drill bit 18 are adapted to be closed during normal drilling operations under the circulating mud pressure. Release of mud pressure allows the valves to open and the fluid in the drill stem to drain out quickly. **Drilling Mud By-Pass for Rotary Drill Bits,** W. D. Myers, Patent No. 2,944,794.




NOW

TOTAL Valve Engineering

W-K-M MAKES REPAIR EASIER



Top left to right: Integral Dual Completion Gate Valve; Integral Triple Completion Gate Valve. *Bottom left to right:* Recessed Body Gate Valve for Triple Completions; Balanced Stem Gate Valve; Standard Production Gate Valve.

Valves designed for fast on-line overhaul prevent major production losses

In many installations, W-K-M Gate Valves have *never* needed overhaul. But when repair *is* needed, W-K-M Valves are designed so *any* internal part—packing, stem, gate or seats—can be easily replaced while the valve is *on the line.*

And even under high pressure, W-K-M Valves permit many repairs which can not be made to other valves without lengthy shutdowns.

Far-sighted design that protects you against such eventualities is an important part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. It's one reason why W-K-M Valves are world-renowned for helping prevent production losses!

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You increase net profits when you perform successful workovers on your wells. Dowell services, products and engineering aids are designed to help you get those added profits. Here are results from a few of many recent jobs.

OPERATOR NETS $4715 IN 90 DAYS FROM ABRASIJET AND ACIDIZING BY DOWELL

ALBERTA, CANADA. Three old wells in the Redwater pool produced an *extra* 4520 barrels of oil in 90 days as a result of Abrasijet*—Dowell's abrasive jetting service—and Dowell acidizing treatments. After deducting total workover and treatment costs from added revenue of $10,115, a net profit of $4715 was realized.

DOWELL SAVES GAS WELL– GETS 10-DAY PAYOUT

SOUTH TEXAS. A Dowell frac job made a 2,750 mcfd producer out of an old Frio well that was practically dead and non-commercial. Payout on treatment was estimated at 10 days.

DOWELL FRAC JOB BRINGS NEW LIFE TO 40-YEAR-OLD GAS WELL

WEST VIRGINIA. 850 mcfd open flow and 200 mcfd delivered into line resulted when Dowell fractured a practically dead 40-year-old gas well. Treatment cost was paid out in less than 30 days.

TREATMENTS WITH VERSENE 100 GIVE 35-DAY PAYOUTS IN PERMIAN BASIN

WEST TEXAS. Average payout of ten treatments by Dowell using Versene® 100 was 35 days. Versene 100 is a chemical used to remove calcium sulfate, calcium carbonate and other scales from wells. Average production increase was 9.7 bopd and treatment costs were between $550 and $875. Net value of oil was assumed to be $2.00 per barrel.

WITH DOWELL WORKOVER TREATMENTS

DOWELL USES "ACID GUIDE"* TO GET FAST PAYOUT ON THREE PROBLEM WELLS

NORTH DAKOTA. Payouts of 55, 23 and 65 days were realized from treatments with Retarded Acid of three old wells in the Madison lime of McKenzie County. Previous treatments using regular acid in the same field had failed to pay out.

NEW ACID TREATMENT SAVES OPERATOR ABOUT $400 PER MONTH ON WATER DISPOSAL WELL

SOUTHEASTERN NEW MEXICO. A single $735 treatment replaced three $650 monthly treatments on a Lea County disposal well. By substituting Stabilized Acid and a surfactant wash for regular acid, life of the job was tripled at an extra cost of only $85. Savings averaged about $400 per month.

FRAC JOB PROVIDES EXTRA GAS AT THREE CENTS PER THOUSAND

NORTH LOUISIANA. 105 mmcf of *extra* gas was produced in four years from a well in the Monroe Gas Field. Reason for this extra production was a Dowell frac job performed in March, 1956. Based on treatment price, the extra gas cost the operator three cents per thousand. 39 similar wells fractured early this year promise to be at least as profitable as the 1956 job.

Talk over your workover problems with your Dowell representative. He will show you how Dowell can use new ideas and techniques to help you cut costs and increase revenue. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina and Germany. Dowell, Tulsa 1, Oklahoma.

* Dowell Trademark

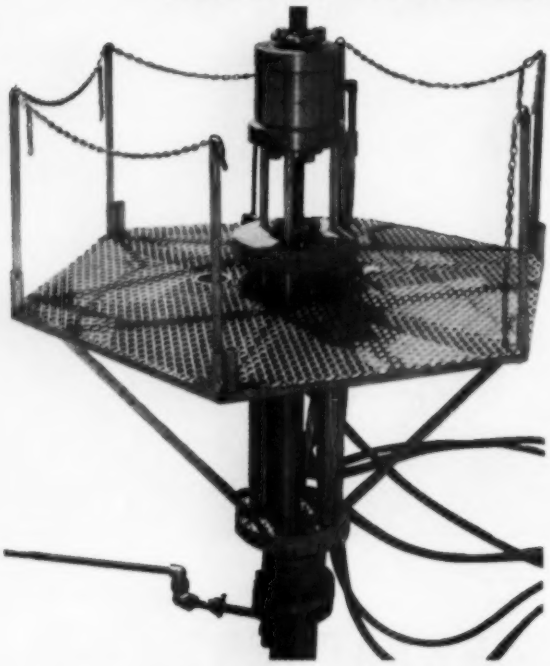
Services for the oil industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

INTRODUCING "Snubby"

BROWN HYDRAULIC SNUBBER AND WORKOVER UNIT



IDEAL FOR CONCENTRIC STRING WORKOVERS

Some of the many operations you can perform under full pressure control with this versatile, money-saving unit:

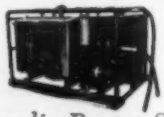
1. Plugged pipe may be pulled, repaired and re-run.
2. Outside or inside cuts may be made to remove sections of pipe which have developed holes or become stuck.
3. You may wash over stuck pipe.
4. An overshot may be run to pick up pipe which has been dropped.
5. A packer may be run or pulled under pressure.
6. A packer or retainer may be pulled safely while it swabs the hole.
7. Pressure controls may be installed on a drilling well when extra high pressures are anticipated.
8. Sand bridges may be drilled out under pressure.
9. Parted tubing may be repaired under pressure.

FIRST IN THE FIELD AND ALREADY PROVEN

Running and pulling pipe under pressure is now a safer, faster, less tedious and cumbersome operation – thanks to the Brown Hydraulic Snubber. Rig and draw works are not needed – wells need not be killed – potential damage to pay zones is eliminated since weighted fluids are not needed – saves time and money with increased safety.

Everything is hydraulic – lifting and lowering, slip actuation and control. Two sets of opposed, double acting slips – one traveling, the other stationary – are hydraulically operated to securely grip the pipe for snubbing in or out. Controls are interlocked so that one set of slips is always engaged.

A remote hydraulic power source, control panel, and all auxiliary equipment is furnished – including a gin pole tall enough to handle a joint of tubing if necessary. Thus workover jobs can be done without moving in a complete rig.



Control Panel includes weight indicator and may be spotted at any convenient place. Hydraulic Power Supply may be located 100′ from well for greater safety.

BROWN
OIL TOOLS, INC.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

RICHARD G. SCHMIDT,
Northern Natural Gas Producing Company,
Hugoton, Kansas

FOAMING AGENTS REMOVE WATER FROM GAS WELLS

Production rates for some water-logged gas wells in the Hugoton field of Kansas were more than doubled by removing salt water with a mixture of foaming agent and alcohol. Hookup is simple and inexpensive.

FOAMING AGENTS MIXED with alcohol and injected into water-logged gas wells by means of a simple surface hookup for both tubed and non-tubed wells have successfully removed from one to five bbl of water daily from 12 problem wells. This novel method put into operation earlier this year by Northern Natural Gas Producing Company in the Hugoton field of Western Kansas has more than doubled producing rates on some of the problem wells slightly less than 3000 ft deep.

On wells equipped with tubing, a 50% mixture of a detergent type foaming agent and 50% alcohol is injected down the casing annulus by means of a gas-pressure-operated chemical injector pump. In wells not equipped with tubing, a 1¼-in. tubing closed on bottom and perforated is run in the well and the foaming agent-alcohol mixture injected down this small tubing.

At this writing, Northern Natural is operating 12 gas wells equipped for dewatering by injecting foaming agents into the well.

This method of dewatering gas wells has worked satisfactorily to date. In general, it was found that wells flowing some 500,000 cu ft of gas daily will unload 4 to 5 bbl of water with four or five quarts of the foaming mixture for a total daily material cost of $2.35. At this writing, no corrosion problems have become apparent on wells dewatered in this manner. A foaming agent designed for use with salt water is employed. Daily volume of foaming agent-alcohol mixture injected into a well will depend upon the amount of water the well is making. A rule of thumb used in these cases has been one quart of the mixture to unload one barrel of salt water. Two installations of this type on deeper wells are also operating satisfactorily. One of the wells is producing gas condensate, and the other is making salt water. The foam breaks out of the condensate after it is dumped from the separator to the pressure storage tank and is drained into a pit.

Early Field Experience

Prior to 1950, very little difficulty was encountered with salt water in the shallow gas wells of the Hugoton field. Since 1950 several methods have been used to relieve water from these wet gas-producing wells. Some operators use siphon strings which work very effectively on wells having a large enough volume of gas to carry the water up the siphon string. Northern Natural Gas Producing Company has several siphon strings in operation on larger volume wells. On smaller volume wells, we installed plunger lifts with a free-traveling piston. The piston operates when there is sufficient water to force it up the tubing. Both the siphon string and plunger lift installations have worked effectively, but we felt a need for a more positive method of removing

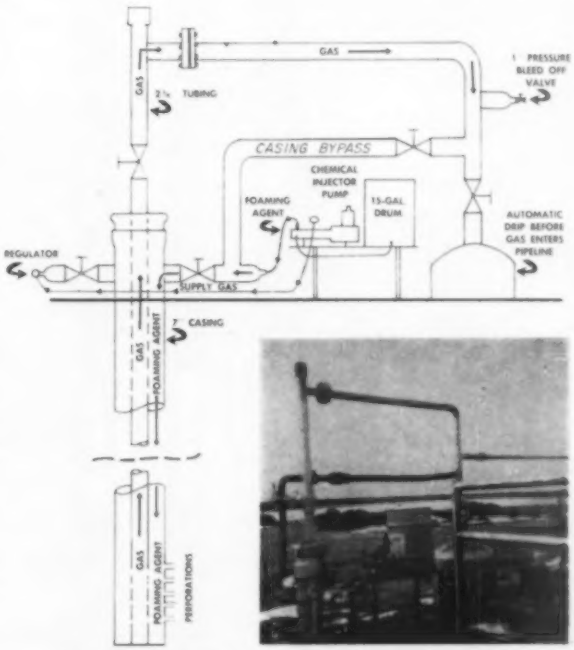
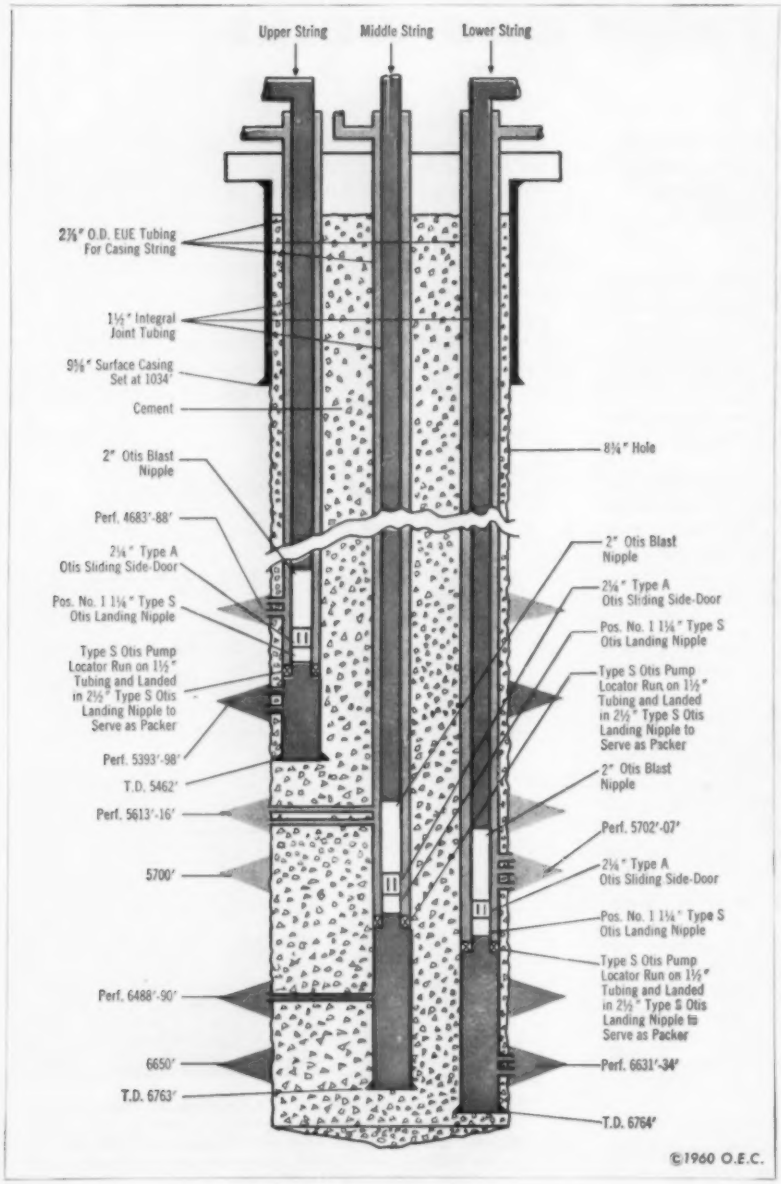


FIG. 1. Gas well hookup for injecting foaming agent mixture by gas-driven pump into casing annulus to produce water from Hugoton gas well. Light water foam is produced with the gas up the tubing into a drip with liquid-level control. Photo shows actual installation setup at well head.

OTIS PRODUCTION NEWS

Volume I, Number 4 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

Otis Equipment Used Exclusively Below Tree in SUNRAY Sextuplet


Upper String
Middle String
Lower String
2⅜" O.D. EUE Tubing For Casing String
1½" Integral Joint Tubing
9⅝" Surface Casing Set at 1034'
Cement
2" Otis Blast Nipple
Perf. 4683'-88'
2¼" Type A Otis Sliding Side-Door
Pos. No. 1 1¼" Type S Otis Landing Nipple
Type S Otis Pump Locator Run on 1½" Tubing and Landed in 2½" Type S Otis Landing Nipple to Serve as Packer
Perf. 5393'-98'
T.D. 5462'
Perf. 5613'-16'
5700'
Perf. 6488'-90'
6650'
T.D. 6763'
8¾" Hole
2" Otis Blast Nipple
2¼" Type A Otis Sliding Side-Door
Pos. No. 1 1¼" Type S Otis Landing Nipple
Type S Otis Pump Locator Run on 1½" Tubing and Landed in 2½" Type S Otis Landing Nipple to Serve as Packer
2" Otis Blast Nipple
Perf. 5702'-07'
2¼" Type A Otis Sliding Side-Door
Pos. No. 1 1¼" Type S Otis Landing Nipple
Type S Otis Pump Locator Run on 1½" Tubing and Landed in 2½" Type S Otis Landing Nipple to Serve as Packer
Perf. 6631'-34'
T.D. 6764'
©1960 O.E.C.

CORPUS CHRISTI – Except for the tubing, all sub-surface production equipment used in the world's first sextuplet producer is standard Otis equipment. And the amount of Otis equipment used in this unique completion is surprisingly small in number and total cost; for example: Only two selective Type S Otis Landing Nipples, one Type S Otis Pump Locator which serves as a packer, one Type A Otis Sliding Side-Door®, and one Otis Blast Nipple were required for each two zones completed. The identical equipment was installed in each of the three strings of 2⅜-inch tubing to permit the six zones to be produced simultaneously and economically.

Otis is the only company which has available a complete range of small diameter sub-surface production equipment to help today's aggressive producing companies complete their slim hole and tubingless wells in the simplest manner. Otis Sub-surface Safety Valves, Sliding Side-Doors, Concentric Gas Lift Valves, Plugs, Plug Chokes, Pack-off Assemblies, and time proven wire line tools make it possible to complete as many zones as practical in the deeper, multi-zone wells being drilled today.

Otis Completion Specialists are available twenty-four hours a day to counsel with you on any specific completion problem. These men are expert in their field and backed up by the complete engineering and development laboratories in the Otis Dallas plant. For complete information on Otis sub-surface production equipment to be used in slim hole and tubingless completions, call the Otis office nearest you or write Otis, Dept. 4-P, Box 35206, Dallas 35, Texas. You'll find experienced Otis Well Completion Specialists ready to help you – anxious to serve you.

OTIS

Engineering Corporation

General Offices:

6612 Denton Drive • Dallas, Texas

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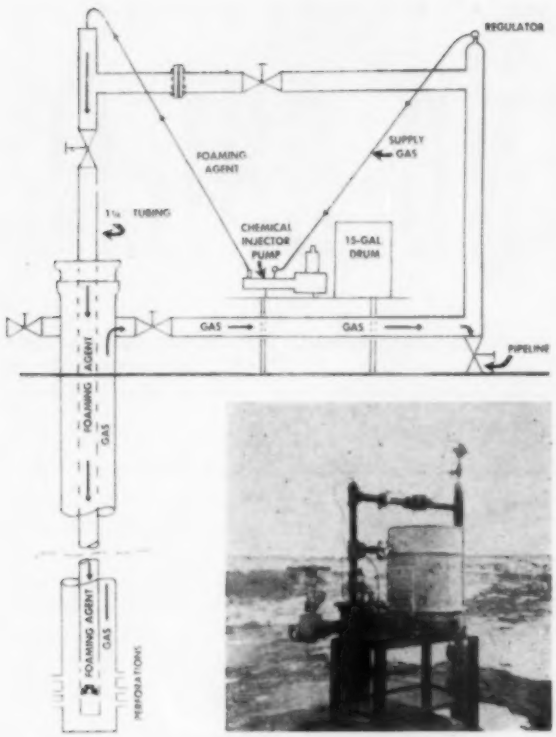


FIG. 2. **Wells not equipped with tubing** can be hooked up for injecting foaming agents by running a 1¼-in. tubing string, closed off on bottom and perforated as shown to introduce the mixture at the bottom of the well. Gas to power the chemical injector pump comes from the well stream.

the water from some "tired" gas wells flowing at low volumes and with increasing amounts of water.

Detergent-Type Agent Used

The first experience with a detergent or foaming agent was on a Hugoton field well in Western Kansas. This well was a good producer, but periodically would log off with salt water. We killed the well and ran a string of 2-in. tubing and installed a plunger lift and automatic dump drip equipped with a liquid level control that dumps accumulated water from the drip. After sufficient time was allowed for the pressure to build up, the well was opened to the atmosphere to unload the water. After 24 hours, the well was shut in so pressure could build up before it was placed on the line. The build-up pressure on this well was 380 psi flowing against a line pressure of 230 psi.

The piston was installed in the tubing string, but it did not function properly. After several attempts at operating the well with the plunger lift system, we found the water was coming in the well at a rate too fast for the plunger lift to operate.

It was decided to try a foaming agent for some experimental work on the water-logged gas wells. The detergent-type agent was mixed with alcohol in a mixture consisting of one gallon of detergent to one gallon of alcohol. A high-pressure pump was used to inject this mixture into the casing and then flushed with water.

The first attempt to unload water with a foaming agent was a treatment of five gallons of the mixture and flushed with five gallons of water. Sufficient time was allowed for the mixture and water flush to reach total depth (2825 ft) before opening the tubing to the atmosphere. The foam mixed with the load of salt water was blown out of the tubing and accumulated on the ground like piles of whipped cream.

The free piston was placed in the tubing and the well was again put on production. Water accumulated in the bottom of the well again and it all but stopped producing. After the fourth treatment procedure outlined above, the well was placed on production and it produced at the rate of about 500,000 cu ft per day for two days. The well was then shut in. After this experience, it was decided that the foaming agent-alcohol treatment would be the answer to the problem of dewatering gas wells in this area.

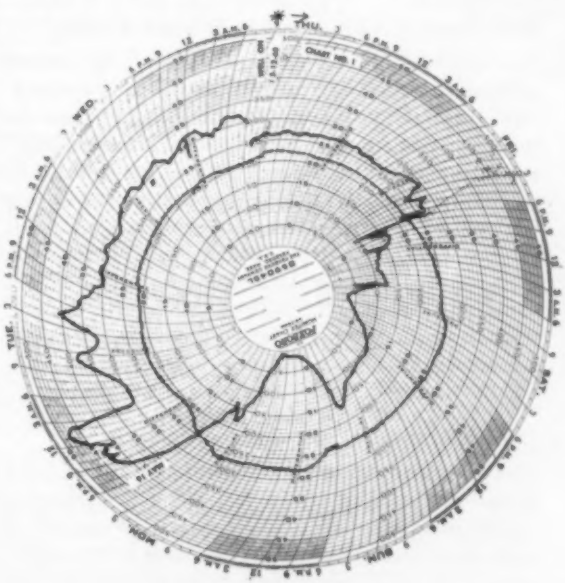
The next step was to find a suitable type pump to inject the mixture of foaming agent into the well without using the high-pressure pump and slugging the well with the mixture. We selected a gas-driven chemical injector pump with a 3/16-in. plunger on the fluid end. This pump can be set to inject from 1/2 pint to 10 gal per 24 hr of operation. A stand was built for mounting the chemical injector pump and a 15-gal drum for a supply tank. This hookup is shown in Fig. 1.

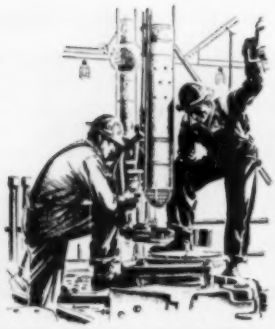
At first, we were uncertain about the mixture setting out in the weather without congealing. After several days of freezing weather, the mixture was checked and found to be of the same consistency as it was when first mixed. By using alcohol with the foaming agent, the resulting mixture is not effected by the weather encountered in Western Kansas. In extremely cold weather, it was necessary to warm up the foaming agent before it could be mixed properly with the alcohol.

One Typical Case History

While it can be said in general that this method of dewatering gas wells has proven very satisfactory thus far, only one typical well will be illustrated to show what results can be obtained. The four gas meter charts to illustrate this case were taken in May and June of 1960 on Northern Natural Gas Producing Company's Lightcap No. 4 well located in Stevens County of Western Kansas.

This well had been loading up after a week or ten days of production. Three gallons of foaming agent down the casing and two gallons down the tubing were used to clean out the well. Pressure between the casing and tubing was equalized for 5 hours and then the well was opened to the atmosphere for 4 hours. The well unloaded through the casing as there was too much water to kick off the tubing.





DRILLING BRIEFS

WELL CEMENTING DATA — REPORT 60-5

Long Interval Squeeze Jobs... an old DIACEL* story.

The recent "something new" talk in industry journals about long interval squeeze cementing with low water loss slurries surprises us somewhat. Especially . . . since our Diacel LWL Cement Systems have been acclaimed for over two years in technical papers, ads, and in the field for efficient squeezing. Just for the record, our Diacel LWL additive was introduced some five years ago for regular cementing jobs . . . specially developed for deep, high temperature wells. Its use for squeeze jobs was a natural consequence of the low water loss and thickening time control provided.

With Diacel LWL, the success of squeeze jobs is almost certain. Slurries are easily formulated with weights from 10.3 to 20 pounds per gallon for a wide range of thickening times. With Diacel LWL, dehydration is practically a thing of the past . . . and the slurry in the casing can normally be reversed or washed out.

First Diacel LWL Squeeze in Western Kansas.

Our early experience and success with long interval squeezes in both deep and shallow wells at all temperatures convinced us that Diacel LWL would be just the thing for Western Kansas fields. The fractured limestone formations in Western Kansas are difficult to seal off, especially if they have been acidized. Squeezing was usually a costly procedure until Diacel LWL slurries were adopted. In looking back through the files, we uncovered the data on the first Diacel LWL squeeze in the area. It was done in Sherman County, Kansas, in the spring of 1958 . . . and, while not as spectacular as some more recent jobs, it did establish our LWL slurries for squeeze cementing in the area.

128 Perforations Over a 249-foot Interval.

This particular well had been drilled to 4958 feet and a seven-inch casing set at 4956 feet with a 20% Diacel D cement using 105 sacks of common and 200 pounds of calcium chloride. Testing was done in seven stages, with a total of 128 perforations being made over a 249-foot interval—from 4459 to 4708 feet in the Lansing Kansas City and Marmaton fractured limestone formations. Six of the perforated intervals were acidized. When the tests proved unproductive, it was decided to convert the well for salt water disposal in the Mississippi formation. In addition, an unprecedented attempt would be made to seal off the entire 249-foot perforation interval in one squeeze with a Diacel LWL slurry. At that time the accepted practice with conventional slurries called for one to two squeezes for each of the seven perforation stages.

Just One Day Needed!

After testing, all bridging plugs were drilled out to 4912 feet and a retrievable packer on 2½-inch tubing was set at 4423 feet. Fluid pressure to the packer was established at 1000 psi. A 15 lbs./gal. slurry was then mixed using 300 sacks of common, 0.3% Diacel LWL and 3% Diacel A (an accelerator). Cement was pumped in stages for 6 hours and 40 minutes before squeeze pressure of 3300 psi was reached.

Saved Two Weeks Rig Time.

After reversing out 11 sacks of slurry and retrieving the packer, the bit was lowered and washed down to 4892 feet. The hole tested dry . . . and the well was deepened through the bottom cement plug into the Mississippi formation at 5003 feet.

In all, squeezing off the perforations and washing down took about a day. Under the old method approximately 10 to 15 separate squeezes would have been required. Conservatively, two weeks rig time was saved by using the low water loss Diacel LWL slurry. As we said before, long interval squeeze jobs are "old stuff" for us.

For complete details and technical data on cost-cutting Diacel Cement Systems for every type of job and well—contact us or your Drilling Specialties representative.

*A trademark

DRILLING SPECIALTIES COMPANY
Bartlesville, Oklahoma

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

A single power source operates both EOT-Johnston Rod Counter-Balanced units shown pumping these offset wells. Units can be operated economically—efficiently—up to 160-acre spacing.

The new EOT-Johnston Rod Counter-Balanced unit is ideal for multiple completions. Can handle any depth . . . any fluid volume . . . and at considerable savings over conventional beam-type units.

6030

EOT

Rod Counter-Balanced

HYDRAULIC UNIT

Now . . .
Pump TWO WELLS for the Price of ONE!

For the operator who needs economical pumping with efficient operation, the new EOT-Johnston Rod Counter-Balanced Hydraulic Pumping Unit is the answer.

The new EOT-Johnston Rod Counter-Balanced unit can pump multiple completions . . . can pump offset wells up to 160-acre spacing . . . and at a saving up to 50% over conventional beam-type units!

The EOT-Johnston Rod Counter-Balanced unit contains a new design valve . . . a special four-way valve that eliminates charging the hydraulic pump suction. Field performance tests acclaim the EOT-Johnston Rod Counter-Balanced unit an engineering "break-through" for the hydraulic pumping method. Now, the economics of hydraulic pumping can be applied to any well, regardless of depth or volume of fluid to be handled.

Write for complete data on the new EOT-Johnston Counter-Balanced Hydraulic Pumping Unit . . . economical . . . efficient . . . pumps two wells for the price of one.

EOT

ENGINEERED OIL TOOLS, INC.

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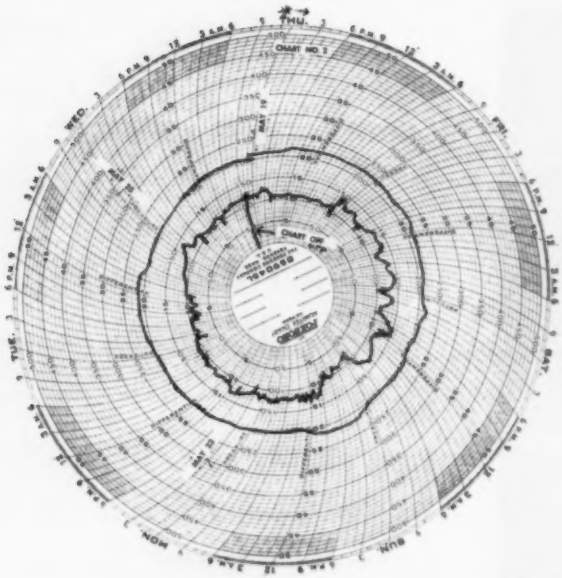
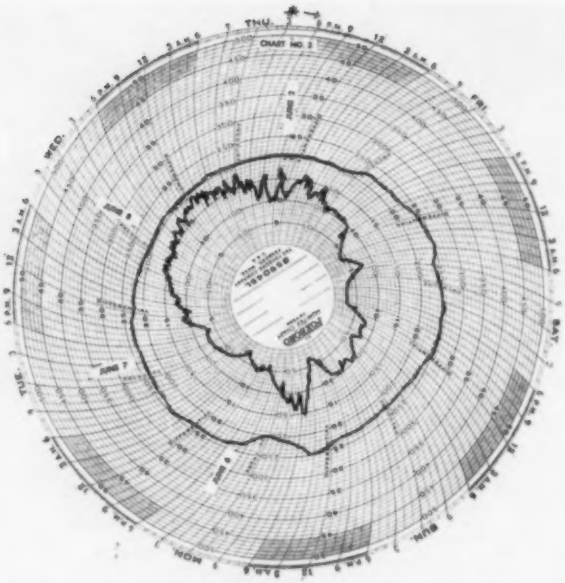
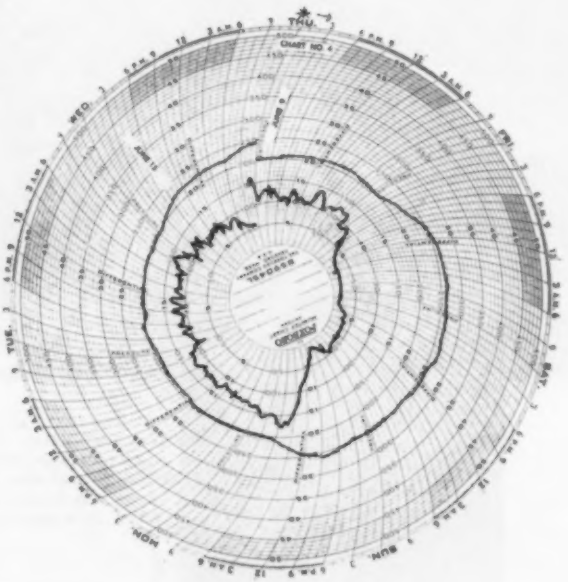
General Offices: 1710 Burnett, Houston, Texas

Distributors:

EOT-Johnston Hydraulic Pumping Units available through your local supply stores in West Texas and Mid-Continent areas. WEST COAST: Lacy Oil Tool Co.; APPALACHIAN AREA: McJunkin Corp.; CANADA: Canadian Well Services, Ltd.; EXPORT: Wilson Supply Co., International Div.







The well was shut in overnight and 5 gal of foaming agent was lubricated down the casing. The well was put on the flow line through the tubing with a 1-in. orifice plate, but after the well failed to flow, the tubing was blown for 10 minutes. Production was then achieved at a rate of 300,000 cu ft per day a week and was then increased to 380,000 cu ft per day.

As the well cleaned up, production increased to 500,000 cu ft daily with a casing pressure of 275 psi. Since the shut-in pressure on the 1960 state tests was 321 psi, the well was working at a 14% drawdown. The dewatering equipment was installed on the well on May 8.

The four meter charts used to illustrate one case show the pressure differential across the orifice in the dashed-line curve. Upstream pressure on these charts is the solid-line curve.

CHART No. 1

When first put into operation with the dewatering hook-up, this well was producing at a flow rate of 440,000 cu ft per day with 215-psi line pressure. During the week of May 12 through May 16, gas flow rate varied according to the line pressure, which ranged from 200 psi to 280 psi. When line pressure increased to 210 psi on May 16, the well flowed through the tubing at 570,000 cu ft per day, but as the line pressure stabilized at 210 psi, the production leveled off at 440,000 cu ft daily and remained such until May 19.

CHART No. 2

On May 19 the orifice plate was changed to 1¼ in. and a new chart installed. With 215 psi line pressure the well was put on the line with a flow of 460,000 cu ft per day. Flow rate increased by 10,000 cu ft with the lowering of line pressure to 200 psi on May 23. On May 25 the well flowed at the rate of 440,000 cu ft daily with 200 psi line pressure and 280-psi casing pressure. The well averaged 470,000 cu ft per day against a 210-psi line pressure and maintained a casing pressure of 274 psi.

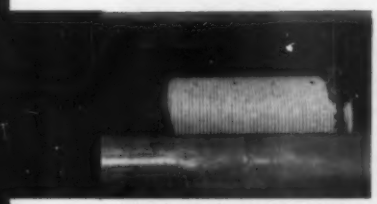
CHART No. 3

On June 6 the well was flowing with a rate of 490,000 cu ft daily against 208-psi line pressure and casing pressure of 265 psi. With the line pressure at 235 psi and the casing pressure at 270 psi on June 6, the well produced 375,000 cu ft per day. With a rise in both line pressure and casing pressure to 240 psi and 280 psi respectively, flow dropped 25,000 cu ft to 350,000 cu ft daily. On the following day, production increased to 540,000 cu ft per day against 205-psi line pressure.

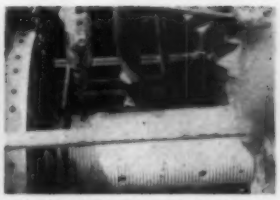
CHART No. 4

The well produced at a constant rate until line pressure increased to 260 psi and flow decreased to only 245,000 cu ft daily. With the lowering of line pressure to 200 psi, flow rose to 480,000 cu ft per day. On June 15 the well was producing 450,000 cu ft daily against a line pressure of 210 psi and a casing pressure of 265 psi. Late in September the well was flowing 400,000 cu ft per day with the use of 2 quarts of foaming agent per day. During the whole month of March 1960 this well delivered 4,689,000 cu ft per day. Production for May was 12,387,000 cu ft and June 1960 saw production of 14,037,000 cu ft with a cost of $24 per month. In April the well was 24,612,000 cu ft underproduced and in July it was overproduced by 3,342,000 cu ft.

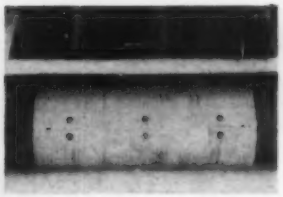
LEBUS ENGINEERED SPOOLING
A boon to well servicing contractors



Split Sleeve clamped in position ready for drilling and tapping of Drum Core.



Drilling being done by hand with 3/4" heavy duty drill for 5/8" cap screws.



After drilling drum core, spacer plate is fitted and welded in completing installation.

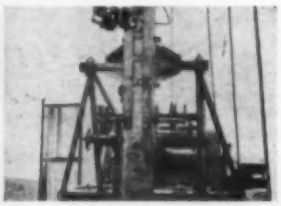
Well servicing unit now ready to spool line off road, 12,200 feet of 9/16" line, 26 layers.

With wire line spooled on grooved drum unit is now ready for rigging up for swabbing job.

First layer of wire line being spooled on LeBus Counterbalance Drum.

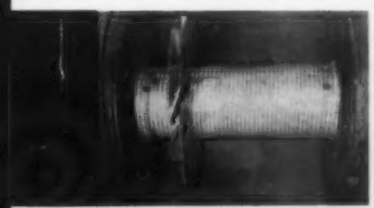
Twentieth layer of wire line spooled on LeBus Counterbalance Drum.

Twenty-sixth layer of 9/16" line — 12,200 feet. Note the perfect uniformity.



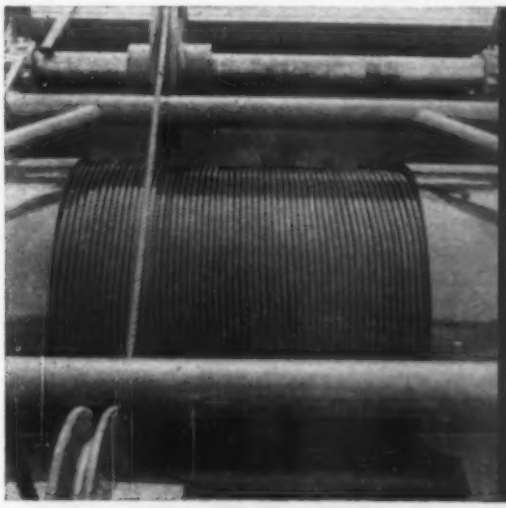
Scene before going back into hole showing floating sheaves which reduces whip and aids with fleet angle.

Below — *actual field scene showing 22nd layer of line being spooled on Spudder drum grooved with LeBus Counterbalance Spooling system — Drum spooling 7,500 feet of 1/8" line serves both the swabbing line and the drilling line. Note how perfectly the line is spooled to the very top of the drum flanges.*



Rod and tubing drum also equipped with LeBus Split Sleeve Grooving (Divider optional).

Another unit equipped with LeBus grooving showing twenty-six layers of 9/16" wire line.



LeBus can engineer your spooling to save you thousands of dollars in manhours, hoisting time and line.

Whether you need new LeBus Counterbalance Spooling that guarantees trouble-free spooling, LeBus Pyramid Spooling or LeBus Helical Spooling, you can count on LeBus engineers to help you. With LeBus Counterbalance Spooling you can avoid waits caused by improper spooling, cutting in, tangled line and excessive wear. Furthermore, LeBus can give you service anywhere and utilize your present drums.

LEBUS INTERNATIONAL ENGINEERS, INC.

LONGVIEW, TEXAS

WORLD HEADQUARTERS FOR ENGINEERED SPOOLING

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new acid base fracturing fluid

Halliburton's ACIDFRAC–50 is a new-improved acid-in-oil emulsion especially designed for fracturing highly acid soluble formations . . . developed to give better performance over a wider range of well conditions.

CHECK THESE IMPROVED FEATURES . . .

- *Stability* — stable during storage and while pumping . . . breaks upon contact with the formation.
- *Fast Breaking* — greatly reduces shut-in time.
- *Resists Re-emulsifying* — easier and faster well clean-up.
- *Easily Prepared* — can be batched mixed or blended continuously with light refined oils or most clean crudes.

Ask your nearby Halliburton man about this NEW addition to the Acidfrac Series. See for yourself the many benefits you get with ACIDFRAC–50.

A working partner in your fracturing operation . . . the Halliburton FRACOMETER . . . ask about it.

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MODEL 60

Mission Slips in 600,000 lbs. capacity slip test machine, with fourteen channel recording oscillograph measuring strains in slips and pipe.

Field and laboratory tests proved that these slips are built like a bridge with plenty of strength but no excess weight. They weigh only 135 pounds; so you won't break your back setting them. Yet, they have all the heavy-duty features you will ever need. You can hold drill pipe with hook loads of 275,000 lb. and drill pipe sizes 2⅜" through 5". The lightweight results from a new design based on sound and proved engineering principles.

Mission Rolling Dog teeth grip the hardest pipe available today with minimum stress concentration. New positive lock retains dogs in place. The standard rolling dogs and new solid inserts let these slips do the job of the heavyweights. You will find all the proved and popular Mission slip features: Segments are self-leveling as insurance against crimping the pipe. Top of slips is constructed to allow heavy elevator blows to be absorbed. Renewable hinge pins on these Lightweight Slips mean long life, less replacement. Flexible handles bend instead of break.

These new slips — built like a bridge — are one more proof Mission knows drilling problems and knows how to overcome them. Available at your supply store.

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Operation of Injection Pumps

At the present time, we are using a gas-diaphragm operated chemical injector pump. This pump can be adjusted to deliver from one pint to six gallons of the mixture in a 24-hr period. Gas consumption to drive the pump under varying operating conditions and discharge pressures is shown in Table 1.

Table 1. Gas Consumption for a Diaphragm Type Injector Pump Operating at Two Input Pressure and Various Discharge or Injecting Pressures and Volumes per 24-hr Period.

Input Gas Press, psi	Pump Strokes Per Min	Injection Press, psi	Chemical Feed Vol, Qts	Gas Consumption, Cu Ft
25	20	100	33	1340
25	10	100	18	691
25	5	100	9	350
45	20	2000	31	1784
45	10	2000	18	880
45	5	2000	9	369

Gas Wells Without Tubing

Two of the gas wells in the Hugoton field that water log periodically were not equipped with tubing. In order to inject the foaming agent-alcohol mixture in these wells, it was necessary to run in the well a special injection string. This string . . . the only subsurface equipment required . . . was 1½-in. tubing hung from the surface and packed off in the wellhead. The lower section of this string was slotted and the bottom plugged. The slotted section was hung opposite the perforated interval of the well. The foaming mixture was injected down this 1½-in. tubing as shown in the schematic diagram of Fig. 2. In this case, foam caused by the presence of salt water in the bottom of the well is blown up the casing.

If the well is tubed, the only equipment required is the surface hookup. It consists of a gas-driven chemical pump with minor wellhead connections and a regulator for supply gas to operate the chemical pump when flowing the well up the casing. The gas supply line should have a dead gas chamber tapped into the flow of gas to eliminate the liquid from accumulating in the regulator and pump. If the pump is installed on the casing to flow the well up the tubing, this chamber is not necessary.

After a few days of injecting the mixture at the rate of three gallons per day we were able to blow the well to the atmosphere and knew from the foam accumulated at the surface a sufficient amount of mixture had been injected to wet the surface of the tubing. The pump was adjusted to feed two quarts of mixture per day. After operating these wells for a six month period, we feel the foaming agent is doing an excellent job of removing the salt water from our gas wells. ★ ★ ★

MEET THE AUTHOR

Richard G. Schmidt is production foreman for Northern Natural Gas Producing Company at Hugoton, Kansas. A graduate of West Texas State College with a BBA degree, he attended the School of Production Technology at Kilgore, Texas. He has worked in Northern Natural's Producing Department for five years, the last two of which have been spent on the problem of de-watering gas wells by the use of foaming agents.

COMMENTS and OPINIONS . . . *from contractors and their customers*

While talking to well servicing and workover contractors around the country, we collected some rather pointed statements which seem to sum up, in their own terms, the major problems now facing the contractors. Some of these statements are printed here as a bit of "food for thought" for all concerned.

Oklahoma contractor:

"Insane bidding practices by some of our competition is our biggest problem. We may go down fighting, but we can't see the future in making unrealistic bids just to keep a rig busy. We believe that if we keep our equipment in good shape, maintain capable crews, and try to compete on a sound business basis, we will come out all right . . . one of these days."

New Mexico contractor:

"We appreciate the confidence a producer places in us when he turns over to us a well in which he has maybe a million dollars invested. And we feel that we can handle the responsibility or we wouldn't take it, but we also feel that some of our customers are lacking in capable supervisory personnel."

Louisiana operator:

"We realize that the labor question is one of the biggest problems that the contractors have today, especially with the profit picture as it is. But the contractor's most valuable asset is a good crew and he's got to do everything he can to get and keep good men. Hiring capable men at a decent wage and giving them safe, respectable working conditions will certainly pay off."

Kansas contractor:

"We bought a couple of rigs from ————nearly a year ago, but we haven't seen any of their representatives since we put the rigs in the field. It sometimes looks like they don't care whether we are happy with the rigs or not, once they get their money. I've got a couple of ideas that I think would improve their equipment, but I don't have time to chase them down to give them my suggestions."

East Texas contractor:

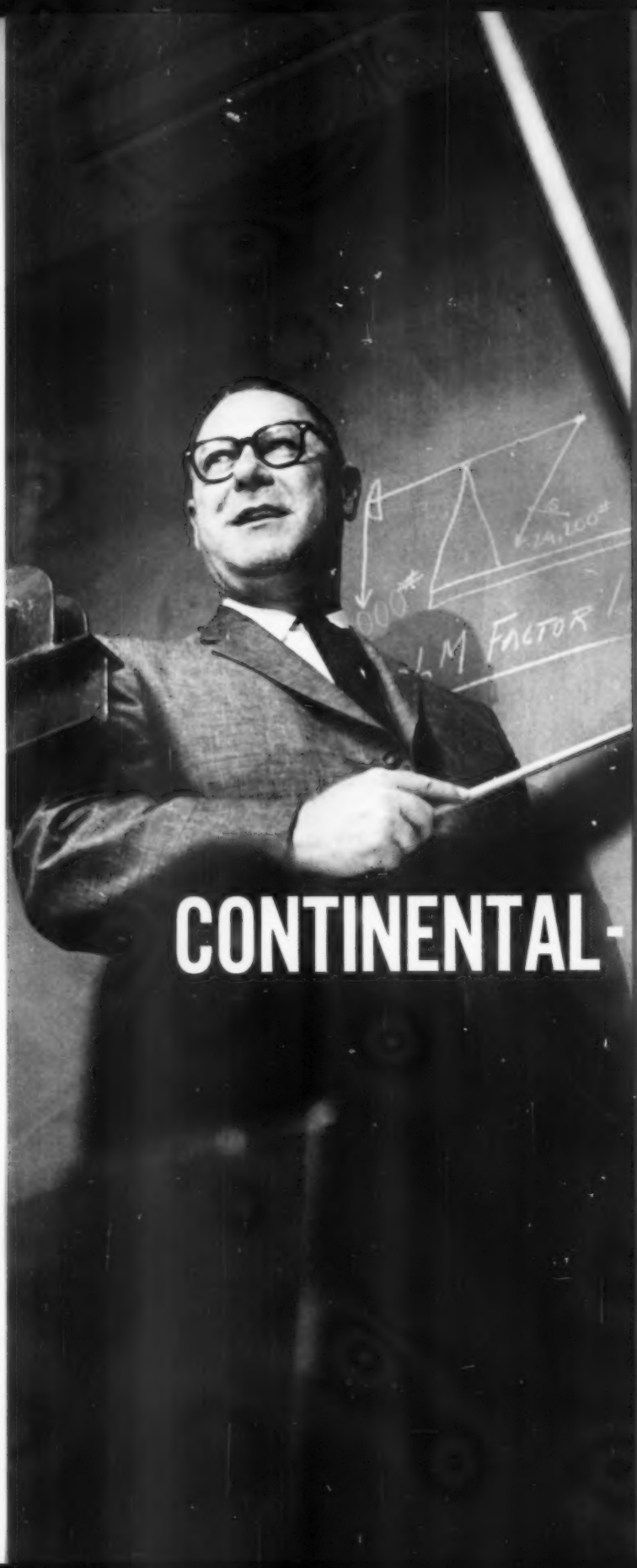
"We are pleased to note that the operators are beginning to realize that we cannot complete a workover program for them strictly on our own operating capital. Our own credit rating has been in danger a couple of times because we couldn't get any payment for our work until the entire program was completed. But this situation is definitely improving and most operators are willing to cooperate with us, especially during extended workover programs."

Insurance representative:

"I don't see how a contractor thinks he can afford not to have a well organized safety program. Too many contractors think that if they provide their crews with hard hats and safety shoes, they've got a good safety program. All the safety equipment in the world is ineffective unless the crews are safety-conscious."

Wyoming contractor:

"We consider our accountant one of the most important men in our organization. We've got to know where we stand every day so that we can keep track of our obligations and our future position. I had a friend who was operating two rigs up here and he thought he could keep all of his accounting on the back of an envelope in his hip pocket. When he finally had to have a thorough accounting of his operations for a tax report, he found out that he was damned near out of business. He managed to pull out of it, but only after he learned a proper respect for a debit and credit ledger." ★ ★ ★



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ABOUT CONVERTING LIFTING COSTS INTO

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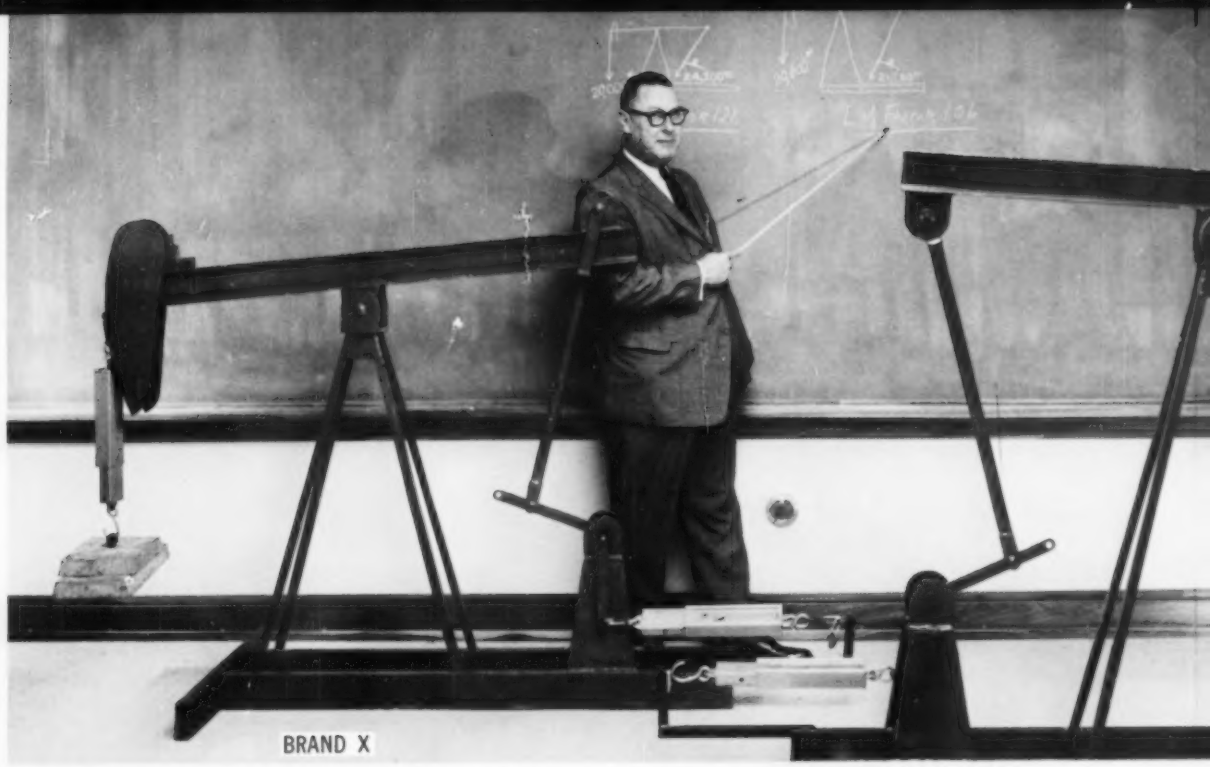
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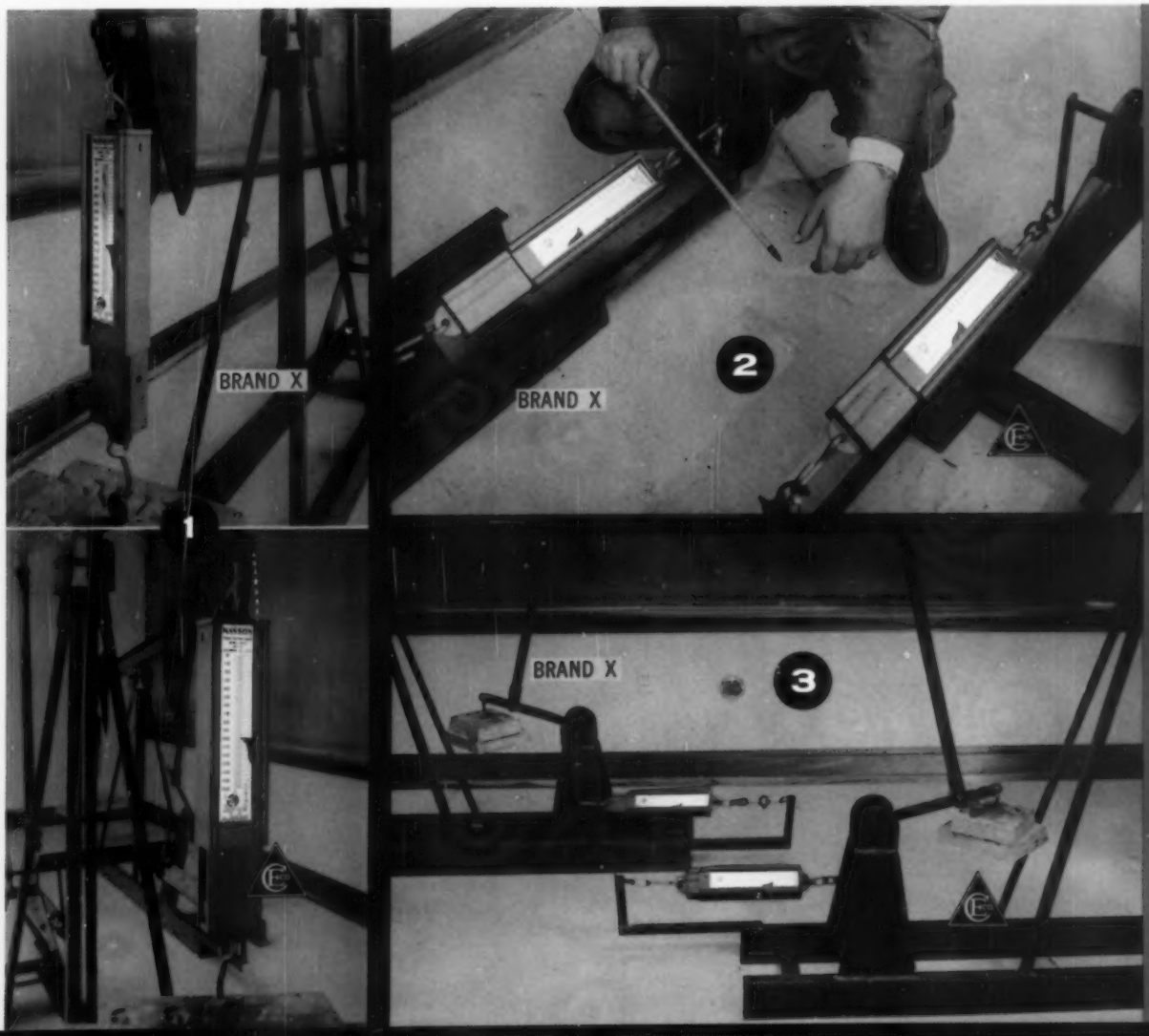
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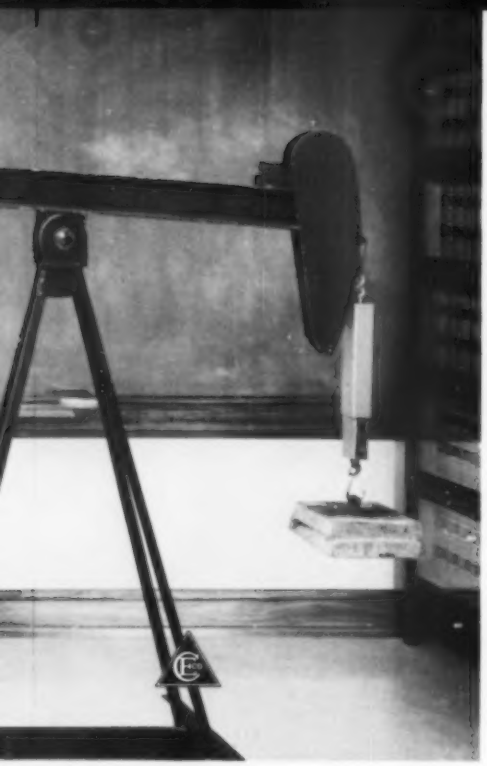

1

These two close-ups show spring scales on the two models in the large photograph. Both read 100 lbs. "well loads".

2

Spring scales attached to the wrist pins of the two models read: 102 lbs. for the C-E-type model on the right; 119 lbs. for the brand "X" on the left *. . over 16% greater wrist-pin load.*

3

With the well load remaining 100 lbs., 50 lbs. of actual counter-balance were added to each unit. The net load at the wrist pin on the C-E reads 34 lbs., while brand "X" reads 51 lbs., a 50% greater bearing and torque load. Obviously the efficiency of C-E's properly-designed unit pays off in lower operating costs, less wear on bearings and gear-teeth, and lower power costs —without over-sizing or purchasing added counterbalance effect.

THIS SIMPLE DEMONSTRATION

. . makes it easy to see how C-E's low LMF (Load Multiplication Factor) cuts your operating costs.

See the two model units in the large photograph? The one on the right conforms to Continental-Emsco's design principles. Note its taller samson post. See how its added height reduces the angle between the pitman and a true vertical line. The smaller this angle, the less is your Load Multiplication Factor. This means you're pulling more vertically and more efficiently, as you'll see in the following example:

On the two models shown, a "well load" of 100 lbs. is applied. With the C-E-type model, the wrist-pin load is only 102 lbs. — a 1.02 Load Multiplication Factor. On the brand "X" model, the wrist-pin load is 119 lbs. for a 1.19 LMF. Seventeen pounds difference. Not much? It represents 16.6% more loading than on the C-E-type model.

To illustrate the advantages of good design, this demonstration is slightly exaggerated, to be sure . . but only slightly. Let's examine the figures from typical full-size unit pumpers and see what the LMF actually can mean to you:

On a 20,000 lb. well, a Continental-Emsco unit pumper with its LMF of 1.06 at its maximum stroke will produce a wrist pin load of only 21,200 lbs. Consider a competitive make with a 1.21 LMF actually being sold today. Here the same well load is increased to 24,200 lbs. at the wrist pin . . a ton and a half greater. Imagine the extra wear on gears, the excessive peak loads on purchased electric power, and the undue strain on belts and bearings!

Now you can see why so much time and effort went into the development of C-E's unit pumper design . . *to offer you the industry's lowest Load Multiplication Factor throughout the line.*

If you speak for your company's management, engineering, or purchasing departments, you should investigate the *many profit advantages* you gain with Continental-Emsco unit pumpers. Make it a point to see your C-E representative or write direct.

NOW LET'S TALK STRUCTURALS

In this unretouched double-exposure, you can see the advantages of Continental-Emsco's *triangular* samson-post design. Here, a load is held solidly by C-E's design, while a platform-type design buckles and flexes under the same load. The two units built of identical materials, are not scale models, but were constructed to demonstrate design principles. Here is a typical result of Continental-Emsco's Research & Development program . . continuing research into better methods of handling your well loads and power requirements with the *utmost utilization* of *each pound* of material.

OTHER FEATURES THAT SPELL ADDED RELIABILITY

PLUS WORLD-WIDE SERVICE AND SUPPLY . . backed by 134 stores and offices

FOUR-LEG TRIANGULAR CONSTRUCTION eliminates weaknesses caused by platform type samson-post design.

SUPERIOR LUBRICATION. Oil troughs cast in reducer case make inspection easier and provide ample amounts of oil at all speeds in both directions of rotation. Structural bearing lubrication available as follows: (1) Standard, from safety ring and ladder (2) ground lubrication (3) prelubricated and sealed at the plant.

BOLT-ON WRIST PIN HOUSINGS cut time for field assembly and stroke-length changes . . make them easier, too. Bolts assure accurate alignment. Pins are hydraulically removable.

B-10 BEARING RATINGS are your assurance of longer bearing life. Another C-E "first."

STANDARD QD SHEAVES cut cost and save time, since they are lower in price and readily available everywhere.

GROUND-LEVEL COUNTERWEIGHT ADJUSTMENTS make well balancing a simple, quick, safe . . and profitable job.

SERVICE BRAKE is a powerful, internally-expanding type and is located opposite drive sheave for easier adjustment and repairs.

VARIETY OF BASES AND SKID EXTENSIONS meets all prime-mover requirements and setting variations.

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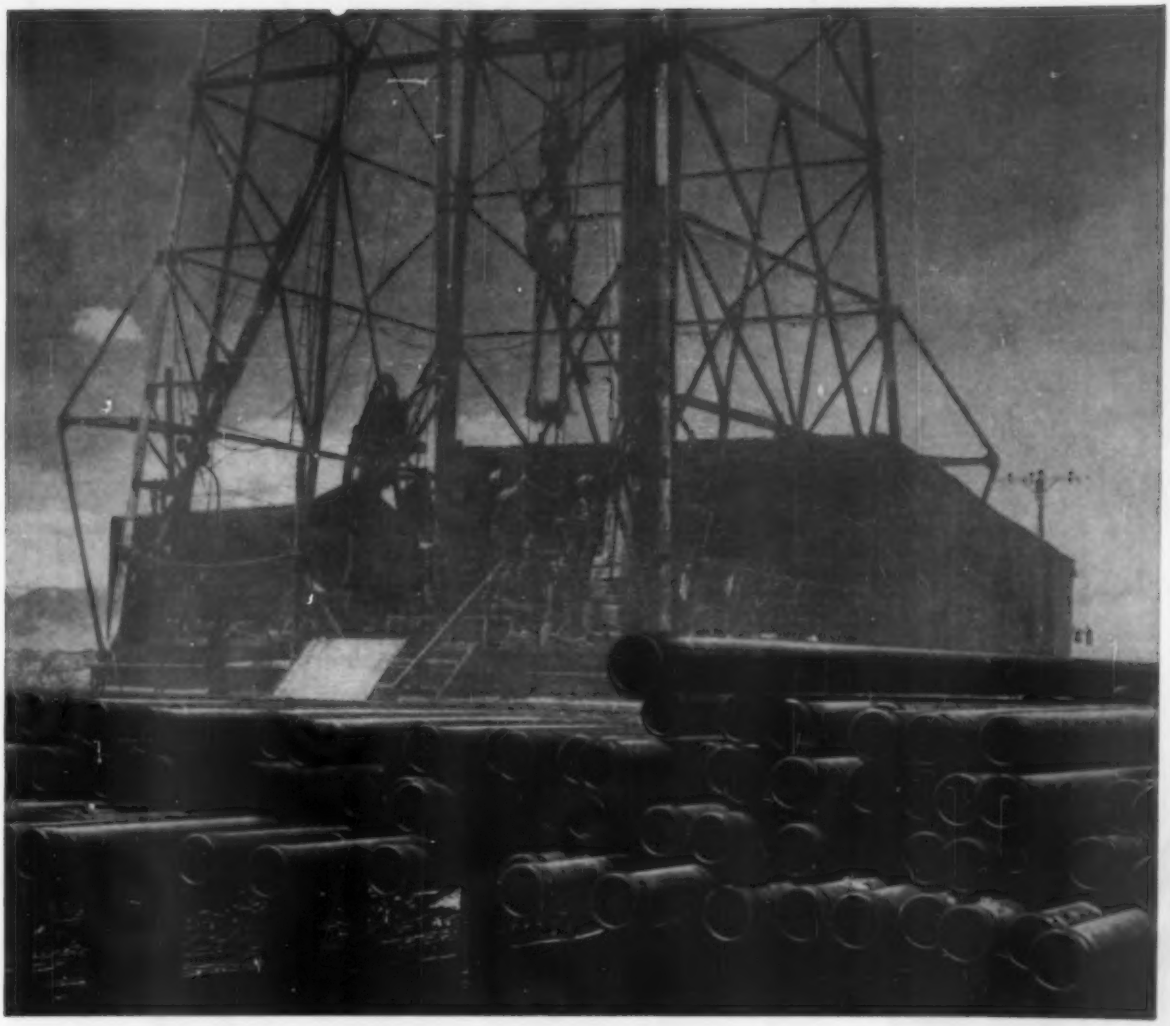

How much CF&I Casing and Tubing *should go into this new well?*

Someone once asked Abraham Lincoln, "how long should a man's legs be"? The president replied, "long enough to reach the ground". The same is true of CF&I Seamless Casing and Tubing. You need enough to protect your investment and bring oil to the surface.

Why should you insist on CF&I Casing and Tubing? Because it is made from top grade steel . . . subjected to strict quality control throughout every stage of production . . . and meticulously manufactured in one of the most modern mills in the industry.

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All CF&I Casing and Tubing exceeds API Specifications. It's available in sizes 2⅜" to 9⅝" O.D. For complete information or technical service, contact a nearby CF&I sales office.

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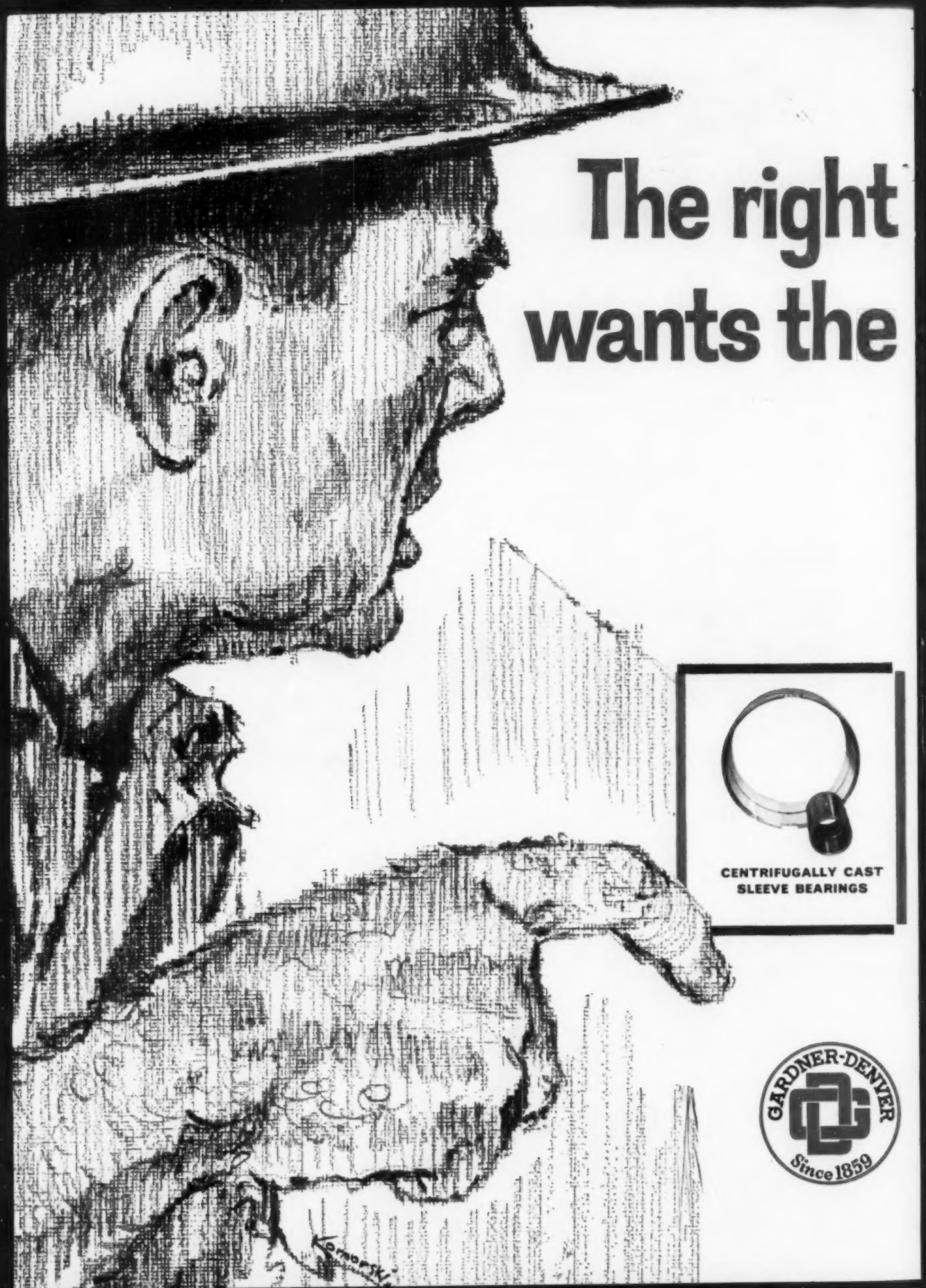

man on the job
right parts in the pump

The tool pusher earns his title through experience.

On the way up, he learns to insist on authentic Gardner-Denver Mud Pump Parts. He learns from experience that only genuine Gardner-Denver Parts are right for Gardner-Denver Mud Pumps.

THE RIGHT MATERIALS—Only Gardner-Denver has complete metallurgical specifications for every part.

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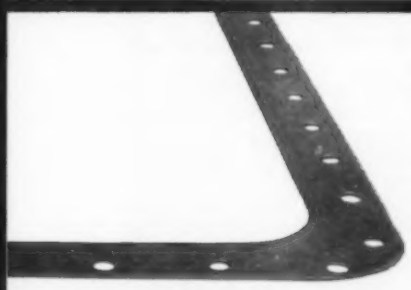
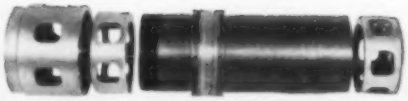
THE RIGHT STRENGTH—Only Gardner-Denver understands full working load for each part.



FABRICATED GASKETS



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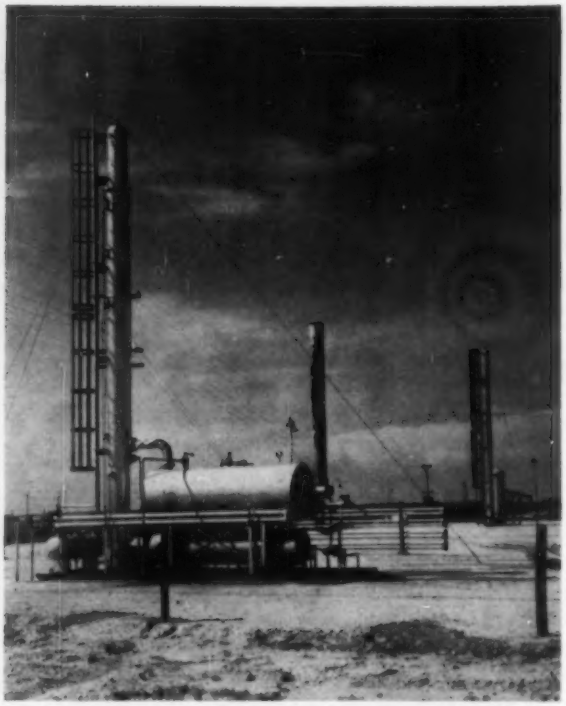
AMINE UNITS SWEETEN SOUR GAS IN THE FIELD

GEORGE ELLIS,
Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma

Economy results from controlling corrosion by acid gases and degradation products, preventing solution losses from reaction with impurities, amine degradation, foaming and mechanical leaks



Sweetening outlet sales gas at 25 psig with this field unit handling 0.53 MMSCFD of sour gas having inlet acid gas content of 10.6 mol percent. Designed to sweeten gas to ¼-grain or less H_2S per 100 SCF, the amine regenerator has a rating of one million BTU's per hour.

OPERATING PROBLEMS are not as prevalent in the amine process of gas sweetening as in some other processes. Still, problems do exist and some knowledge of these problems is important to provide remedies. A brief review of the amine process will be made before discussing specific operating problems, however.

How System Operates

Although there are many other processes for sweetening gas, the amine process is the most popular and has been used successfully for several years. Substantially, all hydrogen sulfide and carbon dioxide removal from natural and refinery gas in the United States today is accomplished by means of the amine process.

It is a process which will remove essentially all the acid gases in a stream. Specifications to ¼ grain or less of hydrogen sulfide per 100 std cu ft are quite common and are easily met with the amine process.

Flows in cycle. The amine process for gas sweetening is a continuous regenerative liquid process. The equipment required is of a rather simple type and will normally operate with a minimum of attention. Since the regeneration of the amine solution is accomplished at near atmospheric pressure and at relatively low temperatures, standard construction of carbon steel materials can be used for the most part.

Favorite solution. In general, it can be stated that monoethanolamine solutions are the preferred solvents for both hydrogen sulfide and carbon dioxide. Principal reasons for the preference of monoethanolamine are its low price, high reactivity, excellent stability, and ease with which it can be reclaimed from contaminated solutions.

Its two principal drawbacks are a relatively high vapor pressure and the fact that it reacts non-regenerably with carbonyl sulfide. Since carbonyl sulfide is a common constituent of refinery gas, the use of monoethanolamine is effectively limited to natural gas and other gas streams which are relatively free of carbonyl sulfide.

Other amines must be used for refinery gas. Most of the following considerations will apply more directly to monoethanolamine, however, since it is the most commonly used amine.

Flow through a typical amine process is shown in the flow diagram. The main equipment components consist of an amine gas contactor, solution stripper, heat exchangers, and pumps.

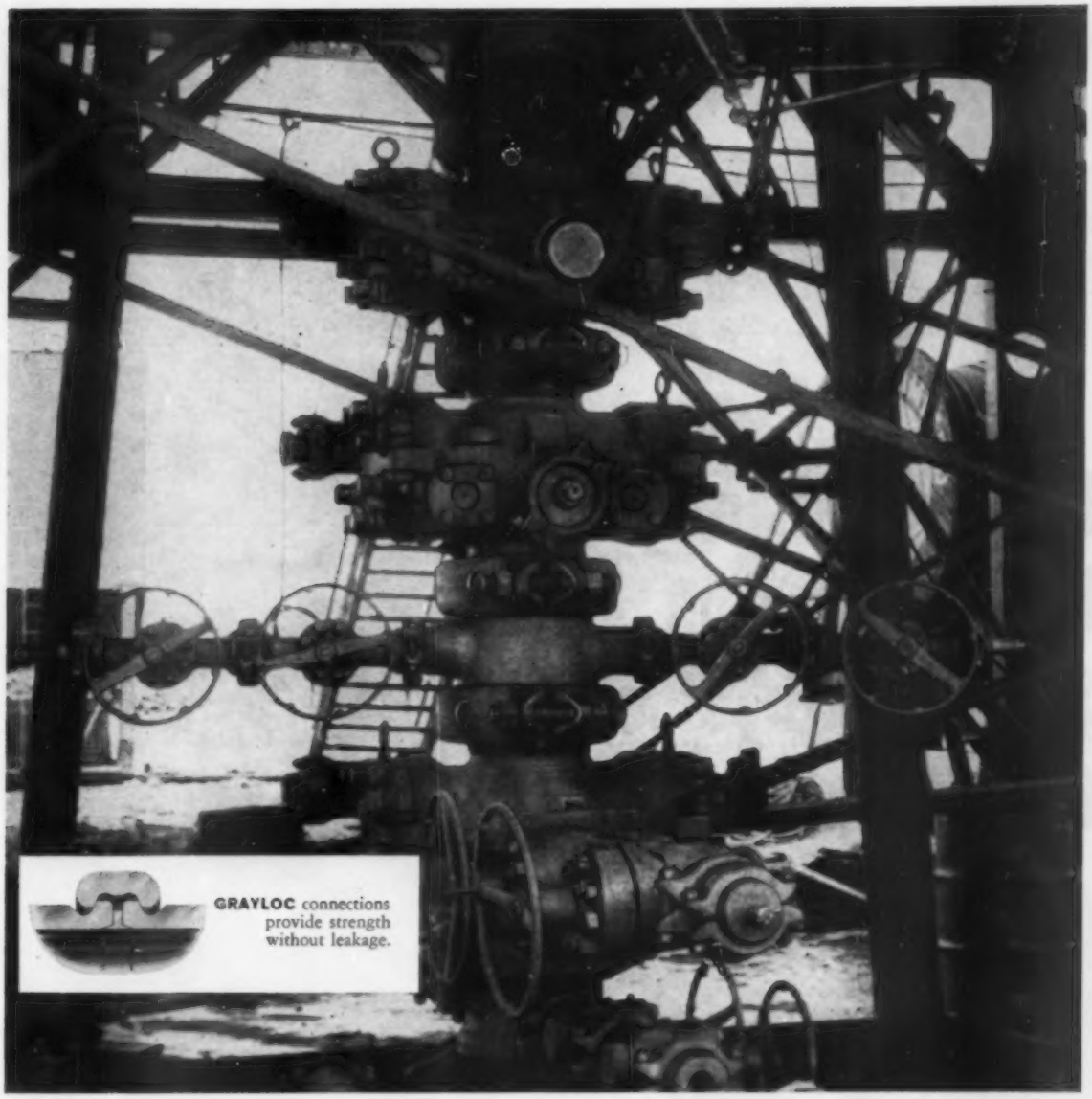
The lean amine is pumped into the top of the contactor and flows downward, making counter-current contact with the sour gas which enters near the bottom and flows out the top as sweet gas.

The amine reacts chemically with acid gas, which contains impurities, that is present in the stream. The acid gas-rich solution is discharged from the bottom of the contactor to an exchanger where it is heated by the hot lean solution.

This rich solution then enters the top of the stripper where it is heated and stripped of the acid gases by steam flowing upward through the column. Thus the chemical reaction between the acid gas and amine is reversed and the solution leaves the stripper essentially free of acid gas.

The lean amine solution flows through the exchanger where it is cooled by the rich solution. The solution is filtered, then further cooled and returns to the main solution pump where the cycle is repeated.

Presented by author at Gas Conditioning Institute, which was held May 11 and 12 in Liberal, Kansas.



GRAYLOC on Well Head and Control Equipment Safely Withstood 7,300 PSI

This all Grayloc assembly, in use on a well in Eastern Venezuela, withstood well pressures of 7,300 psi during drilling operations — proving that Grayloc equipped assemblies provide the greatest possible blow-out protection. The assembly required no additional tightening after the original make-up.

It took a native crew less than six hours to nipple-up this Grayloc equipped well head and control assembly, and it required approximately 24 inches less substructure height than a comparable flanged hook-up.

Learn how Grayloc connections can save you extra hours and money on control systems with complete blow-out protection.

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Rector makes the hook-up that is Sealed with Steel throughout

Rector wellhead equipment is designed to insure a leak-proof seal at all connections. Compare Rector's metal-to-metal seal features with any equipment on the market using resilient packing between casing and tubing strings. The Rector principle of reinforcing temporary organic packing with a permanent ring of steel insures a positive leak-proof completion every time. Rector's built-in welding ring coupled with an API ring gasket is easy to install, immune to corrosion inhibitors, will not flow under high pressure or temperature, will not freeze or contract under low temperature, will not burn out, and never requires maintenance or replacement.

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Now available—a new undercut sucker rod pin specifically designed to take advantage of the strength of the body of the new Type 4 Sucker Rod.

By stress relieving (undercutting) the pin shank, the stress concentration point of the runout thread where pins tend to fail is eliminated.

Available with rolled threads on special order. Also available with conventional API pin.

CHEMICAL ANALYSIS

Carbon	Manganese	Silicon	Chromium	Molybdenum
.39/.46	.65/1.10	.20/.35	.75/1.20	.15/.25

TYPICAL PHYSICAL PROPERTIES

Yield psi	Ultimate psi	% Elong. 2"	% Red. Area	Brinell	Izod
105,000	127,000	22	55	255	70

THE S. M. JONES COMPANY

Division of Buffalo Eclipse Corporation
General Office and Factory: TOLEDO, OHIO
Sales Office: Enterprise Bldg., TULSA, OKLA.
Export Department: The S. M. Jones Company

The acid gas leaves the top of the stripper column along with some excess steam. The steam is condensed and the acid gas passes out to flare or to further processing.

The condensed steam is returned to the top of the stripper as reflux.

Why solution selected. One of the reasons the ethanolamine processes have displaced, to a large extent, some older processes for natural gas purification, is their comparative freedom from operating difficulties. Nevertheless, several factors can result in undue expense and cause difficulty in the operation of ethanolamine units.

Chief among these from an expense standpoint are corrosion and amine loss. Difficulties which occasionally limit the capacity of a plant for gas purification include foaming and plugging of equipment.

Controlling Corrosion

The most prevalent problem in an amine plant is corrosion, and many times there is conflicting information as to its causes and cures. True, each system has its unique set of conditions which determine the corrosion story for that particular plant. However, some fundamentals are involved which will apply to all amine sweetening processes.

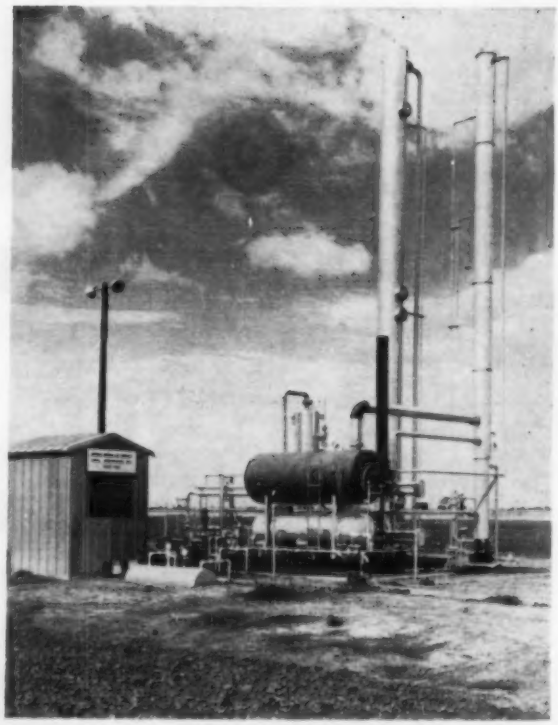
The acid-gas loading of the solution is important in at least two ways.

If overloading of the solution is permitted, the excess acid gas will contribute measurably to the corrosiveness of the solution. Greatest corrosion generally occurs at any point where the acid gases are released in high concentrations or at rapid rates and elevated temperatures.[1] Specific points of trouble are the contactor solution discharge valves and heat exchanger.

Another adverse effect caused by excessive acid gas loading of the solution is amine degradation, the products of which themselves are corrosive. The maximum recommended pickup from a corrosion standpoint is about 30 cu ft of acid gas per cu ft of amine solution. This is equivalent to 4 cu ft per gal or .4 mol of acid gas per mol of monoethanolamine. Under most conditions, amine solutions can pick up perhaps twice this quantity of acid gas before reaching equilibrium.

Underloading of amine solutions presents no particular corrosion hazard. However, it represents excess circulation rate and a consequent waste of utility since the steam requirement in the stripper is almost a direct function of the circulation rate and is not greatly influenced by the gas loading.

Selecting amine concentrations. Another factor to consider from a corrosion standpoint is amine concentrations.



Size and simplicity of typical field installation of sweetening sour gas by the amine process to remove hydrogen sulfide and carbon dioxide.

The choice of amine concentration may be quite arbitrary and is usually made on the basis of corrosion and operating experience, rather than on minimum first cost.

With monoethanolamine plants, concentrations of 15 to 20% are quite typical and occasionally concentrations as low as 10% or as high as 30% are used. Concentrations above 30% can cause problems other than corrosion, particularly when accompanied by excessive acid-gas pickup rates. These high concentrations form a viscous, slurry-like solution that will not readily flow through the valves or heat exchanger.

It should be noted that increasing the amine concentration will generally reduce the solution circulation rate and, therefore, the plant cost. However, the benefits are not as great as may be expected for two reasons.

First, the acid gas vapor pressure is higher over more concentrated solutions at equivalent acid gas to amine mol ratios. This means less efficiency in acid gas pickup.

Second, when an attempt is made to absorb the same quantity of acid gas in a smaller volume of solution, the heat of reaction results in a greater increase in temperature and, consequently, an increased acid-gas vapor pressure over the solution, thus again reducing pickup efficiency. Aside from reduced efficiency, a high temperature zone at the point of greatest reaction will present corrosion consideration.

It is generally accepted that the use of lower amine concentrations results in less corrosion of steel equipment, presumably due to lower concentrations of the amine acid gas compounds in the solution.

Acid gases corrode. Based on corrosion evidence from existing plants, it is logical to conclude that the principal corroding agents are the acid gases themselves.[2] This premise is borne out by the observed increase in corrosion with increased acid-gas concentrations in the solution.

There is no satisfactory correlation available which relates the corrosive attack to be expected with any given ratio of hydrogen sulfide to carbon dioxide.

However, certain generalized observations have been made. It appears that in plants handling predominantly carbon dioxide, very small quantities of hydrogen sulfide may actually reduce corrosion.[2]

Galvanic corrosion. Although it is generally believed the principal cause of corrosion in amine systems is the acid gases themselves, impurities in the solution contribute measurably to the problem. The most general sources of solution impurities are from the gas being treated, from direct oxidation of the amine, or from breakdown of the amine due to excessive temperatures.

These impurities appear as either solids or high boiling-point soluble

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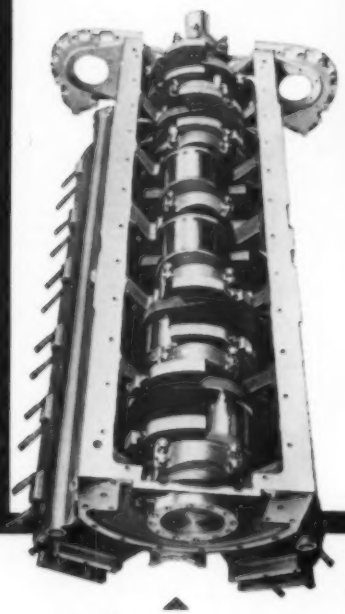

Crankshaft and main bearings in place in a typical Waukesha V-12 oil field engine. Note heavy flanges, thick bearing webs, rugged long-life construction.

Precision-built and balanced rod assemblies, matched with pistons. Pressure oiled, mirror smooth, heavy pins. Replaceable bearing shells.

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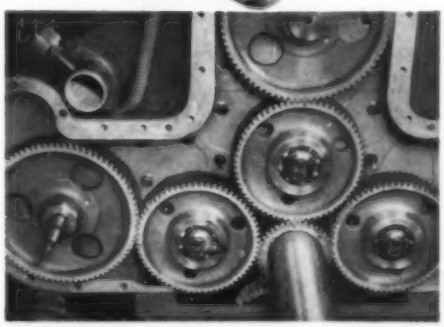
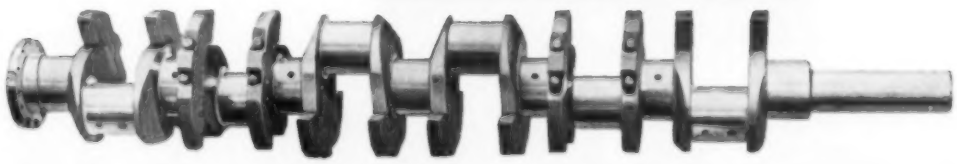


Wide-faced helical cut timing gears are flood oiled. Materials selected for long, quiet life and accuracy. Gears and all elements in the power train, from pistons to flywheel, are precision-machined in Waukesha shops under Waukesha Quality Control.

Rifle-drilled, drop-forged, heat-treated crankshafts, precision-ground to exacting Quality Control standards. Note extra large bearing areas. Statically and dynamically balanced.



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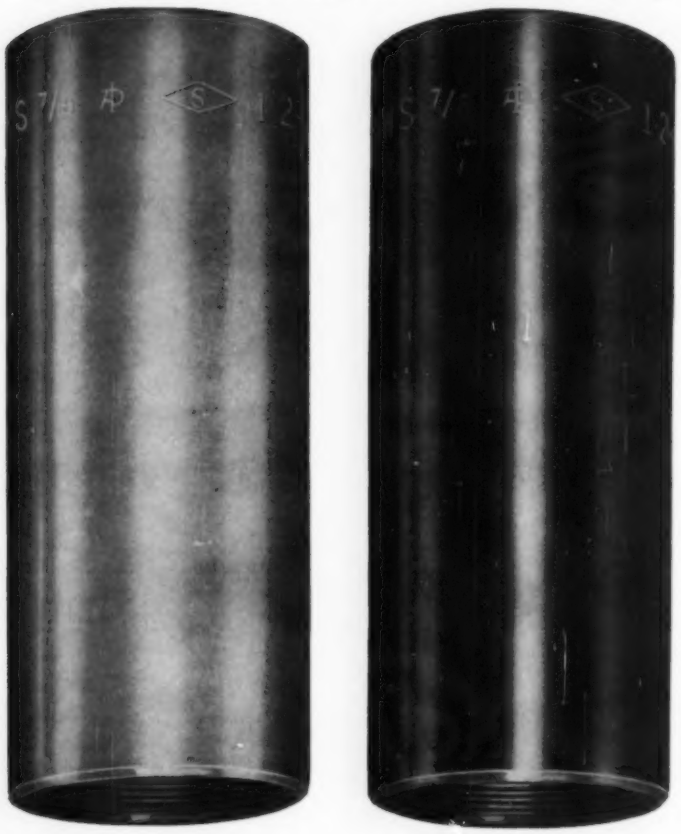

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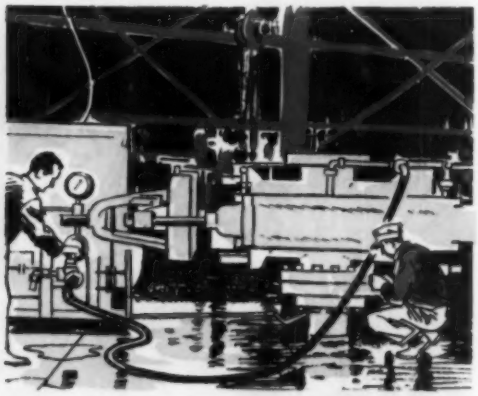

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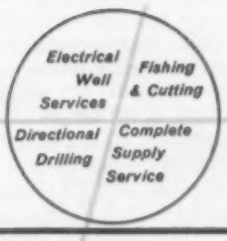

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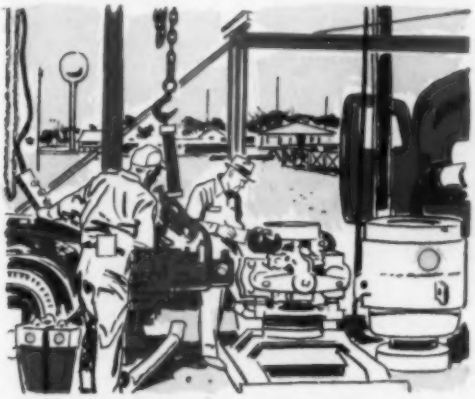

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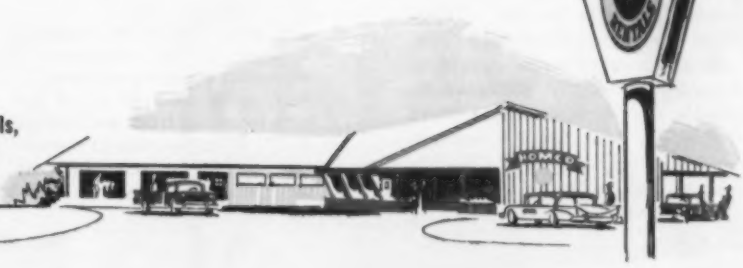


compounds. The solids may be removed by filtration and the soluble compounds by redistillation.

In commercial plant operation, the concentration of amine-decomposition products in the solution should not be allowed to exceed 10% of the concentration of active amine.

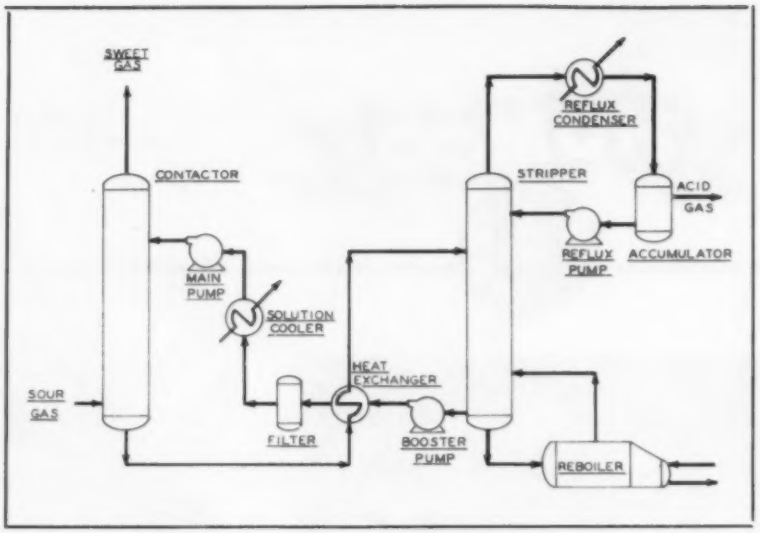
The general appearance of corrosion in aqueous ethanolamine systems is much the same in all plants. It is normally accomplished by an accumulation of suspended solids deposited in areas of relatively low solution velocity. These deposits may contribute to galvanic-cell type corrosion, which leaves pits in the metal surface.

High velocity destroys protective coating. Another type of corrosion common to amine systems occurs at points of high solution velocity. This destruction results from the twin action of corrosion-erosion. Ethanolamines are considered as mild corrosion inhibitors and they are excellent film formers.[3] However, this amine film is not tenacious and will be destroyed by high flow velocities. Also, an additional measure of corrosion protection is obtained, in systems absorbing hydrogen sulfide, from a thick iron-sulfide layer that inactivates the surfaces on which it forms. High fluid velocities will also destroy this form of protection.

Using rust inhibitors. Now, let us consider some measures for prevention and control of corrosion. Rust inhibitors may be the most practical approach to corrosion control in some instances. Usually, it is impossible, or at least impractical, to eliminate all sources of corrosion in a system. Therefore, inhibitors may become an important source of help with the problem.

According to certain patents, 0.1% potassium iodide may be added to monoethanolamine scrubbing solution to inhibit oxidation. Also, it is claimed that the addition of 500-600 ppm copper sulfate inhibits corrosion due to oxidation products.[4] Various proprietary compounds have been reported as successful corrosion inhibitors in monoethanolamine solutions.

Plant design features to minimize corrosion are usually accompanied by increased operating and investment costs and are, therefore, limited by these factors. For example, it would be desirable to circulate a considerable excess of solution to maintain low acid-gas concentration in the rich solution entering the regeneration stage. This, of course, results in larger equipment and additional utility consumption. It must be decided in each case where the economic boundary lies between corrosion prevention and the cost of corrosion itself.



Simplified flow diagram of the amine sweetening process for field installation. Equipment components have been unitized for skid-mounting.

In spite of the economic limitations imposed on the process design, certain features appear to be quite practical. Proper attention to the following factors will minimize the inherent corrosiveness of the solution.

1. The solution should have no contact with oxygen, which should be excluded from the system. This may necessitate blanketing storage and surge tanks with inert gas.
2. The regenerator should be operated at the lowest practical temperatures, preferably in the range of 230 to 240F.
3. Adequate control of suspended solids must be maintained. This is accomplished by filtration.
4. In units where the gas being treated contains oxygen and sulfur, or must operate at high temperature, a reclaimer should be installed to remove the contaminants or degradation products or both.
5. All vessels and welded piping should be stress-relieved to avoid stress corrosion.
6. Solution velocities in heat exchangers should be limited to a maximum velocity of about 3 ft per sec.
7. Rich solution should be placed in the heat exchanger tubes rather than the shell.
8. The plant should be designed mechanically to withstand a somewhat corrosive solution.
9. Any amine solution which has been recovered from system leaks and is to be returned to the system should be returned only through the reclaimer.

Preventing Solution Loss

Solution loss is another serious plant problem. The common causes are foaming, degradation of the amine, and mechanical losses.

Reaction with impurities. Probably the most common loss of solvent is caused by the irreversible reaction of amine with carbon dioxide present in the gas as described by Polderman, et al.[5]

Other impurities in the gas stream, such as acids and oxygen, also react with the amine to form heat-stable unregenerative products. These inactive products can best be removed from the solution by means of a slip-stream distillation reclaimer. The addition of sodium carbonate or hydroxide to the reclaimer will assist in liberation of amine from the acid salts and, thus, increase the amine recovery.

Other loss and leakage systems. Excessive reboiler temperature may also be a source of amine decomposition. There are other important sources of solution loss, such as pump seal or packing leaks, spill losses, and solution waste. These losses are difficult to evaluate and many of us do not bother with the obvious corrective measures to eliminate these losses. The magnitude of these losses sometimes becomes quite surprising.

In a well-designed and well-operated plant, maximum losses should be in the order of one-half pound or less of monoethanolamine per MMscf.

There is a certain amount of amine in equilibrium with the sweet gas out of the contactor and with the acid gases out of the stripper. This is a fixed loss

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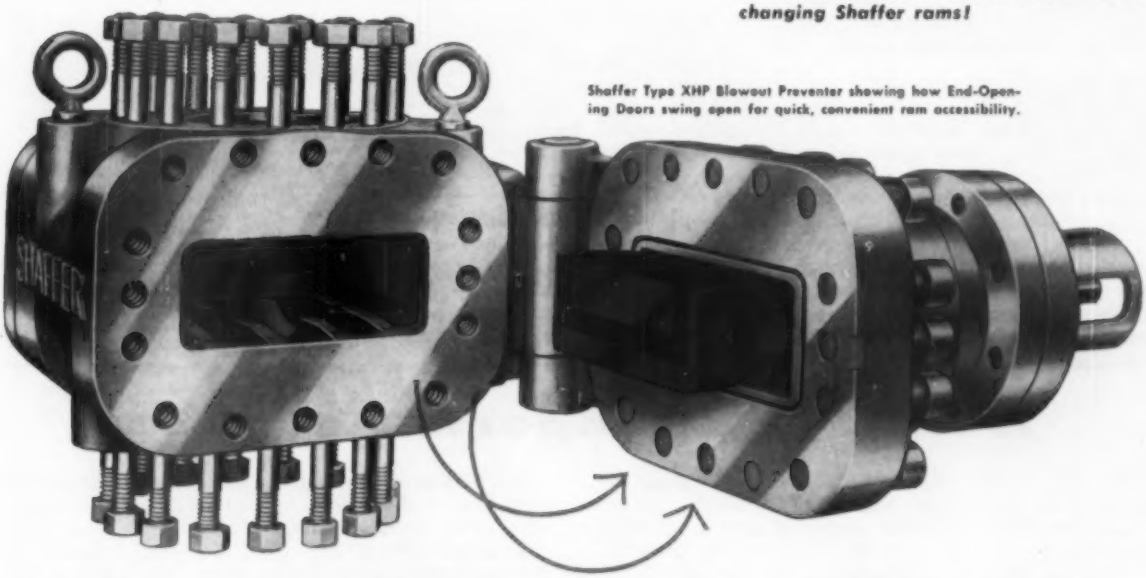

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of solution that must be absorbed as plant operating cost.

Controlling mist. Solution loss from the contactor and stripper in the form of mist, however, can be controlled. Unfortunately, amine mist forms some of the smallest liquid drops known.[6] Therefore, high efficiency mist extractors should be used in these columns.

Causes of foaming. As in the case of corrosion, high amine concentrations are not recommended since high concentrations contribute to high amine losses.

Foaming can be a source of solution loss as well as a limit on the plant capacity. Some of the most common causes of foaming are soluble salts, suspended solids, condensed hydrocarbons, surface active lubricants, and greases, or the use of impure water for makeup.

Of course, the obvious answer to the foaming problem is elimination of the cause, if at all possible. When the foaming is a result of suspended solids, the corrective measures are rather simple and direct. Adequate filtration will eliminate the objectionable solids.

Hydrocarbon condensation contributes to foaming tendencies in plants processing rich field gases. The condensation in the contactor generally results when the lean amine is cooled to a point below the temperature of gas being purified.

Also, at low flow rates in cold weather, hydrocarbon condensation can occur in the contactor due to atmospheric cooling, particularly in uninsulated columns.

Actually, aqueous amines have very little affinity to absorb hydrocarbon constituents in the gas. Should light hydrocarbons build up in a solution, they are easily removed at the reflux accumulator.

When the foaming is a result of soluble salts, condensed hydrocarbon or lubricants, the cause of the problem is more difficult to detect. A remedy can usually be found by trial and error if one is persistent in his efforts. However, it is generally more expedient to rely on laboratory tests for determination of the best agent or best remedial measures for licking the foam problem.

Sometimes solution redistillation is required; sometimes a treatment with activated charcoal will stop the foaming. There is some evidence to support the belief that when the surface tension of the solution is the same, or near the surface tension of a new solution, foaming will not occur.

If the foam results from temporary or accidental plant upset, anti-foam agents may be used. Anti-foam agents should be used with caution, since they are no panacea for all foaming problems. In fact, the problem may be aggravated if the wrong agent is used, or if used in excess.

As stated earlier, it is usually more expedient to seek the advise of a laboratory for foam problems in amine plants.

Highlighting Efficient Operation

In highlighting some of the considerations surrounding amine plant problems, particular emphasis was given to corrosion and solution losses, with foaming being discussed as part of the latter. To summarize, corrosion is primarily caused by (1) acid gases, (2) degradation products.

Some measures which will reduce corrosion include temperature control, solution concentration and acid gas pickup control, solution reclaiming to eliminate degradation products, removing suspended solids, with filters, and addition of corrosion inhibitors.

Solution losses result primarily from (1) amine reacting non-regenerably with impurities in the gas being treated, (2) degradation due to oxidation or high reboiler temperature, (3) foaming, and (4) mechanical losses. Recommended control measures are, excluding oxygen from the system, using lowest possible reboiler temperature, controlling foaming by keeping solution clean or by use of anti-foam agents, and observing good practice in maintaining mechanical equipment.

One of the most important points to remember is that solution loss and excessive corrosion go hand-in-hand with dirty solutions. Good dividends are realized by keeping an amine solution mechanically and chemically clean.

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★ ★ ★

IPAA Seeks Imports Revision

THE OIL IMPORT ADMINISTRATION was urged recently to change its basis for limiting imports east of the Rocky Mountains from nine percent of total demand for petroleum products to ten percent of demand for crude oil.

This was the major recommendation contained in an eight-point proposal to reduce oil imports other than residual fuel, submitted to government by the Independent Petroleum Association of America.

If applied to 1960, the IPAA proposal to relate District I-IV imports to demand for crude oil would result in a reduction of about 170,000 bbl daily in imports other than residual fuel.

Adjustments already proposed by government would, if put into effect now, reduce imports about 60,000 bbl daily. IPAA commended these proposed adjustments as recognizing "continued unhealthy conditions in the domestic (oil) industry," but said further import cuts would be necessary to restore "a vigorous, healthy petroleum industry in the United States."

The national oil producers' organization stressed the fact that imports have increased out of proportion to the rise in domestic crude oil production, as a result of basing import allocations on total petroleum demand.

While District I-IV imports exclusive of residual fuel have been kept at about 10% of total product demand since 1954, the ratio of imports to crude oil demand has risen from 10.7 to 12.6%, and the ratio of imports to domestic crude production has jumped from 11.9 to 14.2%.

It noted that the rise in imports in ratio to crude oil demand since 1954 "is equivalent to an increase of approximately 135,000 bbl per day."

IPAA cited several advantages in basing imports on crude demand. Among them: Imports would be prevented from increasing in relation to (domestic) crude oil production; both imports and domestic production would increase in keeping with requirements; necessity of "periodic adjustments" to compensate for such factors as rising residual fuel imports would be eliminated.

Crude oil production in Districts I-IV was 2000 bbl per day less in the first six months of 1960 than in 1957, the year that government determined that oil imports must be limited. By contrast, IPAA pointed out, demand for petroleum products rose more than 600,000 bbl daily in this period. "The entire increase in demand of more than 600,000 bbl a day was met from sources other than domestic crude oil production," IPAA said.

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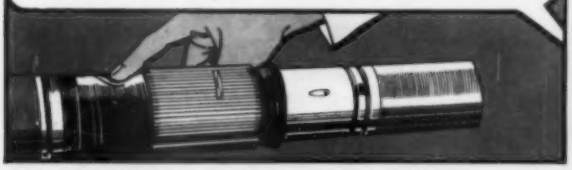
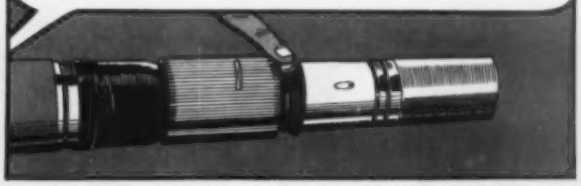
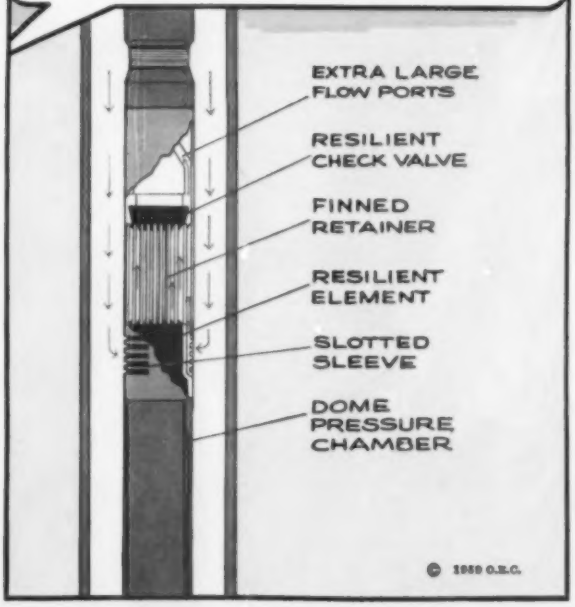
Here, let me show you the many advantages of the resilient elements in our valves. First, because this main element is resilient, it resists erosion from the system gas. Second, the flow area across the element is the largest flow area of the valve, which not only helps to reduce any cutting action from the system gas but minimizes the movement required to admit gas from the annulus during operation. These features are designed to prevent fatigue.



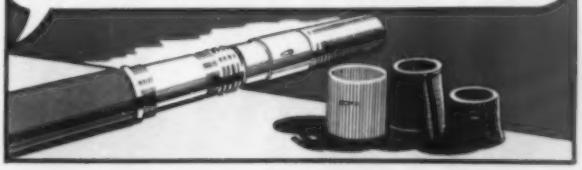
The same principles apply to the check valve here. It compresses just slightly as gas passes over it, then —when necessary to check back pressure from the tubing—it acts to form a bubble-tight seal against the finned retainer and inside wall of the valve. And the rubber-to-metal seal principle of both resilient elements eliminates the excessive wear normally associated with metal-to-metal, stem-and-seat type valves.



I'll show you how we bond the main valve element to the valve mandrel assembly in a minute—but first let me show you this flow diagram of our Type C Gas Lift Valve. Pressure from the valve dome holds the main valve element closed across the slotted ports. When gas pressure in the annulus exceeds the set pressure of the valve, the main valve element opens. When the pressure from the annulus drops below the set pressure of the valve, the valve closes.



Now here's how we bond the main valve element to the valve mandrel assembly. First we serrate the sealing surfaces of the mandrel assembly to give it a superior bonding surface. Then we apply a special bonding cement, slip the rubber element into place, and bake the complete assembly for one hour at 375° F. This produces a pressure-tight seal at the element end of the dome chamber. As a result, our valves can be expected to maintain their set pressure indefinitely.



If you're planning a new gas lift installation and want to RUN VALVES THAT WILL STAY IN THE HOLE and give you trouble-free service — INSTALL OTIS GAS LIFT VALVES. They have no moving metal parts . . . no bellows to fatigue . . . no metal seats to cut out . . . and they're designed to operate continuously or intermittently without having to be pulled for conversion. Contact one of our gas lift specialists at the Otis office nearest you. He'll be glad to show you these and other exclusive features and explain how Otis Gas Lift Valves are designed to save you money.

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Acoustic log checks casing cement jobs

C. H. THURBER • B. F. LATSON, *Pan Geo Atlas Corporation, Houston, Texas*

Basic characteristics of this relatively new logging principle have been adapted to "look" behind the casing for flaws in the bond, for fillup as well as cement tops

INHERENT CHARACTERISTICS of the acoustic log have made it possible to apply this relatively new logging principle to another significant oil field use: checking casing cement jobs. In any casing cementing operation, it is important to obtain a good bond between the cement and the formation as well as between the outside casing surface and the cement. It is also important to know if the cement has solidly filled up the annulus . . . or, if there are pockets of mud trapped in the cement sheath surrounding the casing.

It is equally important to know in many instances precisely where the top of the cement column is located in relation to the surface. If a well is to be worked over involving re-perforation, it is essential to know the condition of the cement behind the pipe throughout the interval to be tested.

By modifying and redesigning the formation acoustic logging tool, Pan Geo Atlas Corporation engineers have developed this new acoustic cementing log called the Sata Cement Log.

The theoretical principles of this cement log have been demonstrated simply by striking a glass with a knife, which produces a ringing sound, as contrasted to the sound which is heard when the glass is held by one hand. It follows that holding the glass with only two fingers will dampen the sound a noticeable amount. Unbonded and tightly cemented casing responds to sound energy in much the same manner, and the modern sound wave amplitude recordings make possible the study of these conditions.

Two single receiver acoustic curves are run. One is the original single receiver curve which measures the short-

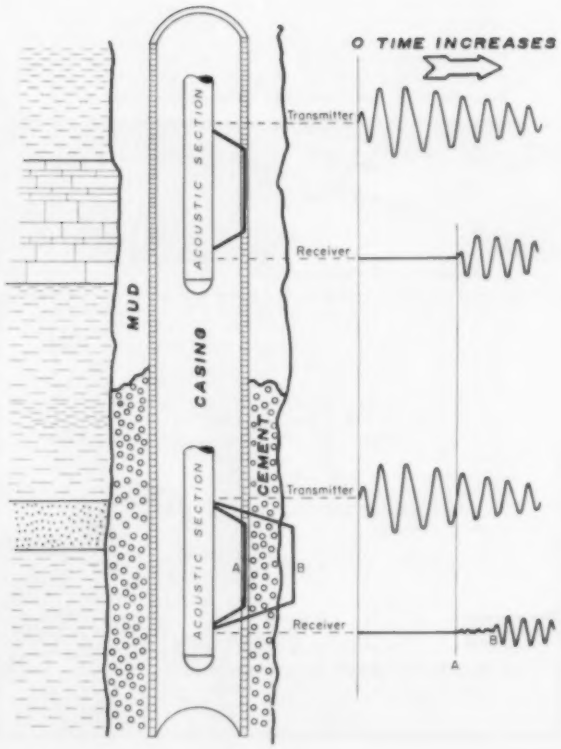
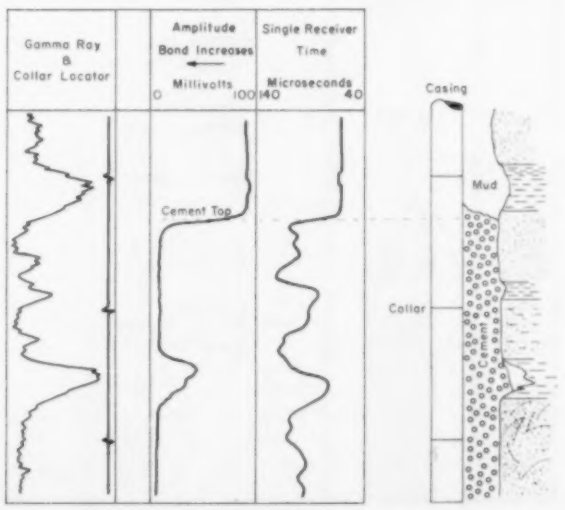


FIG. 1. **Amplitude character** of the acoustical cement log showing the basic principle of detection and measurement.

FIG. 2. **Idealized response** of acoustical cement log in comparison to downhole conditions. Note that a gamma ray and collar locator increase the amount of valuable data obtained.



stam'-i-na vigor: capacity for enduring
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The exceptional stamina of the Oilmaster Subsurface Hydraulic Production Unit is not a result of chance. From swab nose to hold-down this unit is designed with a capacity for enduring. In installations under a packer, in high gas oil ratio wells, and in wells where the fluid produced is abrasive, the Oilmaster Hydraulic operates at efficiencies previously believed impossible and with only a minimum of maintenance. Ask your Oilmaster representative about the stamina of this versatile unit. Have him tell you about the Flood Valve—how it eliminates fluid pound and lubricates the wear parts of the pump, or write for Bulletin E5903.

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In 1940 the Fluid Packed Pump Co. introduced a totally new concept in tubing pump design—the Oilmaster Tubing Full Liner—the first tubing pump ever to employ a one-piece hardened and honed full liner, and the first pump ever to combine the simplicity of a one-piece liner with the high precision and abrasion resistance of hardened and honed alloy steel tubing.
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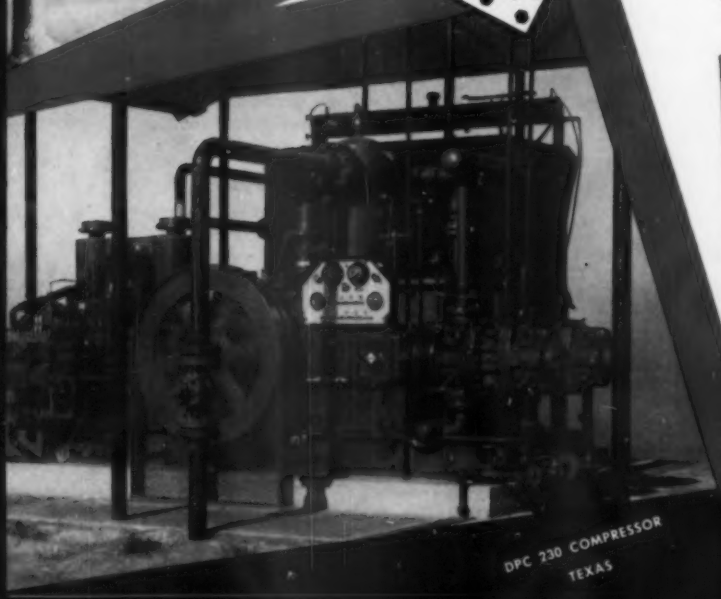

DPC 230 COMPRESSOR
TEXAS

DPC 115 COMPRESSOR
CALIFORNIA

est transit time between transmitter and receiver. The new curve is a plot of the amplitude of the sound wave carried by the casing as shown in Fig. 1. To make the log even more valuable, a gamma ray curve and collar locator are run by the same tool (See Fig. 2).

Transmission amplitude curves (TA) were first presented with signal attenuation curves (SA) on the open hole qualitative SATA acoustic log now in common use on the Gulf Coast. Other types of cement logs previously have established the direction of cement bonding quality as increasing to the right side of the logging grid. The amplitude curve of the new acoustic log for cement inspection has been reversed from that of its former acoustic log counterpart to conform with this standard. Good cement bond is indicated by low amplitude (weak receiver signal), while poor bonding is recorded as a higher amplitude. Maximum signal strength shows no cement bond.

Interpretation of Log

There are a number of facts to remember when analyzing such a log. Cement is a slurry until it hardens and the quality of the sound signal in the casing is dependent on its solidification. Contamination of the cement slurry can completely alter the setting time. Mud packs or dirty pipe can prevent the cement from bonding to the pipe. Crooked holes may cause casing to be against the wall of the hole and, therefore, prevent the cement from bonding all around the pipe. This is a common form of channeling clearly shown on this new log.

The effect of using centralizers and scratchers on the casing is widely known and has been well illustrated on the logs. Above the top of the completely cemented section, it seems to be common to have sections of cement separated by mud voids which might or might not be troublesome.

Bonding Quality

Obviously poor bonding to the formation is as serious as poor bonding to the casing. The single receiver curve recorded with the amplitude is an indicator of this bonding quality, for the travel time through the rock strata will correlate best with open hole logs or the gamma ray when the formation cement bond is good.

If a high amplitude signal at casing velocity is observed, there may be cement but no bond. This is just as bad. A squeeze under these conditions will take very little cement and tends to cause the operator to disbelieve the log. The quality of a squeeze job is not necessarily proportional to the number of sacks of cement used.

Casing collars appear as low amplitude and low velocities (longer time). Since these conditions are also indicators of good bonding, care should be exercised not to misinterpret these points on the log.

Well Site Data Required

All information relative to the cement job should be included on the log heading at the well site. The following, and even other considerations, should be available for best interpretation of the acoustic log: (1) calculated top of cement; (2) zones in which loss of circulation occurred; (3) accurate mud displacement or cement return; (4) a knowledge of casing movements during cementing; (5) accurate measurements of centralizers and scratchers from casing collars; and (6) zones of hole bridges.

Improving Squeeze Jobs

Analysis of the acoustic log in a number of cases has pointed the way to the successful re-working of older wells where previous routine squeeze jobs and recompletion efforts would have resulted in the wells being plugged and abandoned. In fields where new wells are routinely squeezed before every completion, the cement log has clearly shown the problem, thereby allowing the completion costs to be reduced substantially. ★ ★ ★

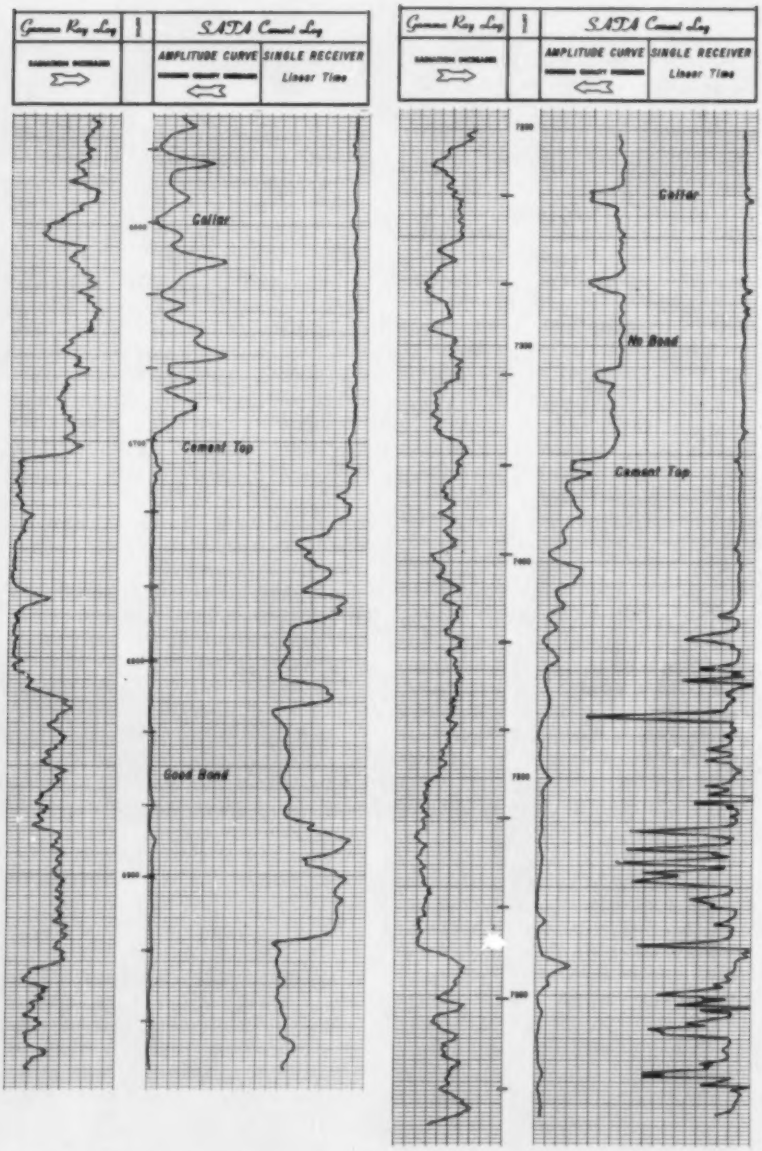

FIG. 3. **Good and bad cement bonding** are indicated on this cement log that shows what the final survey looks like and some points of interpretation.

ATLAS EMULSIFIER cuts $17,675 From Mississippi Drilling Costs

Savings in bits and rotating hours on Arkansas Fuel Oil Corporation's R. L. Everett No. 1 in Magee Field, Mississippi, cut contractor's drilling costs $2.53 per foot, based on $50 per rotating hour, when compared to the company's previously drilled Lavon Womack No. 1. Both wells were drilled in the same field and under almost identical conditions . . . except for the mud employed. Whereas the comparison well was drilled with a caustic-quebracho mud of higher weight and viscosity, R. L. Everett No. 1 utilized a low-solids oil-in-water emulsion made with an Atlas emulsifier.

Operator, Arkansas Fuel, and contractor, Larco Drilling Company, attribute extended bit life and increased penetration rate directly to the drilling fluid.

DRILLING RECORD COMPARISON

	R. L. Everett No. 1	Lavon Womack No. 1
Mud	Trimulso Emulsion	Caustic-Quebracho
Interval	5,050-12,857	4,955-12,403
Feet Drilled	7,807	7,448
Bits	38	47
Feet/Bit	205.4	158.5
Wt. on Bit	25,000-70,000	25,000-36,000
Rotating Hrs.	317	630
Feet/Hr.	24.6	11.6
RPM	80 to 130	70 to 140
Bit Size	9⅞	9⅞
Pump Size	1-16"	1-20" 1-16"
Liner Size	6	6¾

$2,025 saved

$15,650 saved

Atlas emulsifier is sold through distributors under these tradenames . . . each is the product of Aquaness Department, Atlas Powder Company:

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ATLAS EMULSIFIERS IMPROVE A GOOD DRILLING FLUID
Because Atlas oil-in-water emulsion muds provide better oil action, they improve hole conditions, extend bit life, and increase penetration rates.

Better Hole Conditions. Atlas oil emulsion decreases torque as much as 50% . . . the hole is kept cleaner and pump pressures are correspondingly lower. There is less danger in lost-circulation and low-pressure zones.

Longer Bit Life. Atlas oil emulsion prevents balling, provides better cutter and bearing lubrication. Greatly extended bit life reduces bit costs, reduces rig hours lost to trip time.

Faster Drilling Rates. Atlas oil emulsion makes more feet of hole per hour. Oil lubrication combines with improved hole condition to increase drilling rates in competent and troublesome formations.

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Aquaness Department, Atlas Powder Company
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What's doing in DRILLING

Wide-Open Substructure Designed For Big Well Heads

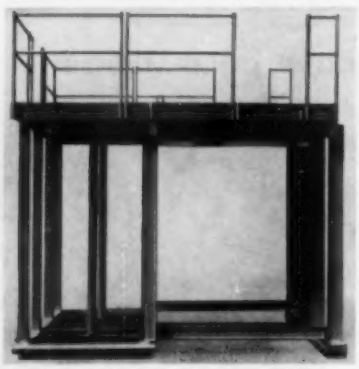


Photo courtesy Cardwell Manufacturing Company.

New wide-open substructure has been designed for big well heads, multiple flow lines, and big fracturing or treating heads.

Designed for maximum speed in rig-up and rig-down operations, substructure can be set in place around the well head and the trucks released. After nippling down, drop-in rotary table and floor sections can be put in place with the traveling block. When substructure is completely assembled, a large wide-open area of 7 ft 4 in. by 16 ft remains clear around the well.

Substructure is available in various heights.

Remote Controls Planned With Lunar Drilling System

First phase of a contract for a lunar drilling system to be rocketed into space by an unmanned space ship sometime in 1963 has been completed.

Purpose of the project is to learn more about the composition of the moon, its atmosphere, and conditions that would affect future manned explorations. Jet Propulsion Laboratory of California Institute of Technology, administrator of a multi-million dollar project sponsored by the National Aeronautics and Space Administration, is considering a lunar drilling system developed by Hughes Tool Company of Houston, Texas.

Lunar drill is miniature by oil well drilling standards. It stands 5 ft high, is made of exotic metals, and will weigh 60 lb on earth and 10 lb on the moon. It will drill a small-diameter hole to a depth of several feet and will be capable of penetrating dust or granite-like rock. This is necessary because the composition of the moon's surface is unknown.

Plans for a type of space ship capable of delivering a load of 600 to 800 lb to the moon, including the lunar drilling system and other instruments, are being developed by several aircraft companies and the laboratory.

Electronic command will move drilling system from the space ship and place it into operation. Samples of moon's surface will be analyzed by some means such as X-ray diffraction and radioed back to earth.

AAODC Creates Committee For Sound Practices

A sound practices committee has been formed by the American Association of Oilwell Drilling Contractors. This significant development will substantially broaden the association's scope of activities and mark their entry into an entirely new phase.

"Due to the increasing frequency with which undesirable and inequitable drilling conditions are being imposed on drilling contractors, the board of directors announced, "AAODC is initiating steps to deal with such problems."

In authorizing the formation of this new committee, the board expressed the opinion that it was "desirable and necessary to improve drilling conditions imposed on contractors by producers and to encourage drilling contractors not to accept conditions imposing unreasonable risk of financial loss."

After this board action, committee members appointed were William P. Clements, chairman, Southeastern Drilling Company, Dallas; Jack Abernathy, Big Chief Drilling Company, Oklahoma City; R. C. Tucker, Great Western Drilling Company, Midland, Texas; Mark Gardner, Delta Drilling Company, Dallas; and Max E. Peden, True Drilling Company, Casper, Wyoming.

Advanced Drilling Course Completed at Texas A&M

The third session of the Advanced Drilling Engineering Course offered the industry by the Petroleum Engineering Department of Texas A&M College has been completed.

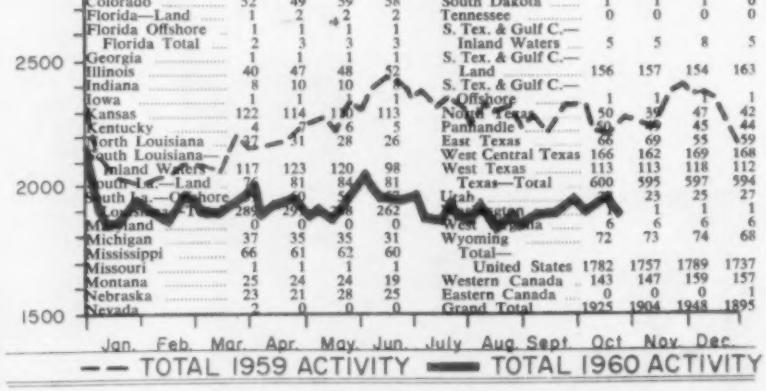
Lectures were given by the engineering faculty and oil industry representatives. Subjects covered included a study of the drilling rig, optimum conditions for rock penetration, factors affecting the rate of penetration, formation evaluation, drilling economics, hydraulics, and methods of reducing drilling costs.

Next course is tentatively scheduled for April of 1961.

Rotary Rigs Operating in Oil Fields of United States and Canada

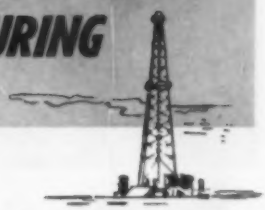
As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

	Sept. 26	Oct. 3	Oct. 10	Oct. 17
Alabama	3	2	2	2
Alaska	7	7	7	7
Arkansas	11	10	12	13
Arizona	1	1	2	2
California—Land	84	72	67	68
California—Offshore	3	3	2	3
Calif.—Total	87	75	69	71
Colorado	52	49	59	58
Florida—Land	1	2	2	2
Florida Offshore	1	1	1	1
Florida Total	2	3	3	3
Georgia	1	1	1	1
Illinois	40	47	48	52
Indiana	8	10	10	8
Iowa	1	1	1	1
Kansas	122	114	110	113
Kentucky	4	7	6	5
North Louisiana	27	31	28	26
South Louisiana— Inland Waters	117	123	120	98
South La.—Land	76	81	84	81
South La.—Offshore	70	70	70	77
Louisiana Total	285	294	282	262
Maryland	0	0	0	0
Michigan	37	35	35	31
Mississippi	66	61	62	60
Missouri	1	1	1	1
Montana	25	24	24	19
Nebraska	23	21	28	25
Nevada	2	0	0	0
New Mexico	104	95	106	105
New York	2	2	2	2
North Dakota	16	14	15	17
Ohio	6	6	5	4
Oklahoma	155	168	179	170
Oregon	1	1	1	1
Pennsylvania	8	8	9	8
South Dakota	1	1	1	0
Tennessee	0	0	0	0
S. Tex. & Gulf C.— Inland Waters	5	5	8	5
S. Tex. & Gulf C.— Land	156	157	154	163
S. Tex. & Gulf C.— Offshore	1	1	1	1
North Texas	50	39	47	42
Panhandle	50	49	45	44
East Texas	66	69	55	59
West Central Texas	166	162	169	168
West Texas	113	113	118	112
Texas—Total	600	595	597	594
Utah	23	23	25	27
Washington	1	1	1	1
West Virginia	6	6	6	6
Wyoming	72	73	74	68
Total— United States	1782	1757	1789	1737
Western Canada	143	147	159	157
Eastern Canada	0	0	0	1
Grand Total	1925	1904	1948	1895



TUF-PROP

A SUPERIOR PROPPING AGENT FOR WELL FRACTURING



Recent laboratory and field applications have shown that carrying capacities of hydraulically induced fractures can be materially increased in many cases through the use of rounded walnut shells as a propping agent. These applications show that Tuf-Prop (Rounded walnut shells) is superior to sand as a propping agent in formations of such hardness that will effect the crushing of sand.

You may expect these advantages:

1. Greatly increased permeability of propped fractures in "hard-rock" formations.
2. Greater radius of propped fracture with no increase in volume of fracturing fluid.
3. Reduction of time required for bottom-hole cleanup after fracturing job.
4. Elimination of abrasion by propping agent on bottom-hole and surface equipment if "flow-back" occurs.
5. Walnut shells are practically inert to reactions of oil, water and acids.

When sand is crushed within a fracture, an aggregate of integrated particle size is formed. Fluids flowing through the fracture transport the finer particles of crushed sand and form partial blocks, often in the vicinity of the wellbore. These blocks reduce the flow capacity of the fracture. The capacity of fractures in which the propping sand is crushed is often only a *Few Hundred* md-ft*, regardless of whether a monolayer or multilayer pack is obtained. Through the proper selection of fracturing fluids, pumping facilities, and rounded walnut shells, fractures with capacities up to 35,000 md-ft can be obtained. (Fig. I)

This phenomenon is brought about by the fact that a partial monolayer of shell, in a concentration of approximately 20 grains per square inch or 0.7 lb. per gallon, is deposited in the induced fracture. As the injection pressure is reduced, the overburden settles, the shell particles are deformed but remain intact, rather than shatter as a grain of sand. (Fig. II)

A greater radius of propped fracture may be expected through the use of walnut shells because of the difference in densities of walnut shell, sand, metal pellets, glass beads, etc. The density of shell is approximately ½ the density of sand. Consequently, if the same fracturing fluid and injection rate are used, the shell will be transported a greater distance into the induced fracture before settling occurs.

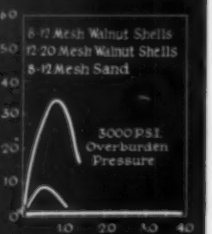
The time consumed in bottom-hole cleanup after a conventional fracturing job with sand can be considerable if a screen-out occurs that leaves the wellbore packed with sand. The low concentration of walnut shell (usually ¼ to ½ lb. per gal.) greatly reduces the chance of a "screen-out". However, should a screen-out occur, the shell remaining in the wellbore can be readily circulated out. This is due to the fact that the rounded shells do not pack into a semisolid mass.

Once a well is fractured, the fracture serves as a "pipeline" between the formation and the wellbore. Often the production is dependent on the capacity of this "pipeline" between the oil in place in the formations and the wellbore. Therefore, it is important that you prop the fracture in such a manner that it has the capacity to carry the potential production. Judicious design of fracturing fluids, pumping rates, and shells for propping can produce a fracture having these desirable characteristics. Intrusion of shell into the extremity of the fracture produces capacity at the point of greatest fluid collection. Greater capacity, adjacent the wellbore where the high capacity is most needed, can be poduced by proper selection of grain size. At the present time, rounded walnut shells are available in three popular grain sizes: 8-12 mesh, 12-20 mesh, and 20-40 mesh.

***md-ft may be defined as the permeability of the fracture in millidarcys, multiplied by the fracture width in feet.**

CAPACITIES OF PROPPED FRACTURES IN "HARD" FORMATIONS

EXAMPLE PLOT



REACTION OF PROPPING AGENTS TO LOADING

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AQUAVAP

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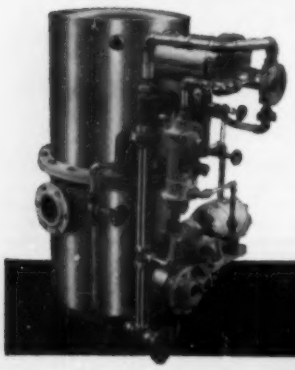

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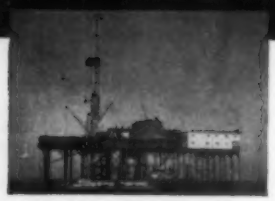

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- FRESH WATER FROM SALT OR BRACKISH WATER
- 5 MODELS WITH CAPACITIES OF 150 GPD TO 12,500 GPD

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6 MILL LANE, WATERFORD, CONN.

Air Drilling Firm Begins International Operations

International Air Engineering, Inc., a Nevada corporation, has opened an office in Oklahoma City at 221 Northwest Fifth Street. Officers of the company are Leo W. Rice, president, George P. Stanison, vice president, and Bill B. Rice, secretary and treasurer.

This latest expansion by an air drilling firm reflects the growth of this technique on an international scale through firms offering specialized service.

North Africa looms as a prime prospect for the immediate future since formations encountered are particularly suitable for air drilling.

Halbouty Urges Drilling More Exploratory Wells

Reservoir engineering data indicate that Texas oil and gas operators have drilled at least 100,000 unnecessary development wells at a cost of some $10 billion, Michel T. Halbouty told a chapter of American Petroleum Institute at a meeting in Victoria, Texas.

If the $10 billion had been spent on exploration, he asserted, "I know . . . that we would have found many billions of dollars worth of new oil and gas which would have been of tremendous benefit to the economy of this state."

The Houston oil operator and geologist blamed overdrilling on regulatory practices based on conditions which existed in the 1930's, before reservoir engineering developed, and urged Texas oil men to do everything possible to change rules and regulations to effect a remedy.

Halbouty said he drew his $10 billion estimate from the assumption that each of 100.000 "unnecessary" wells cost $100,000 — a figure he said reflected current wells costs.

The problem has grown more acute in the 1960's than in the 1930's, he said, because the number of Texas oil and gas fields has increased to more than 6000 from fewer than 1000 and the number of Texas wells has increased to around 200,000.

Attacking small-tract drilling as detrimental to the taxpayer and oil consumer, whom he described as the real "little man", he said that small-tract drillers find no petroleum, but always arrive after discoveries are made and boosting production costs.

Halbouty advocated enactment by Texas legislators of compulsory pooling, as distinguished from compulsory unitization, discontinuance of arbitrarily selected allocation formulas, and adoption of temporary spacing rules in each area immediately after completion of discovery.

FIG. 1. Wellhead end of the walking beam shows how this sheave, along with another on top the sampson post, replaces the temper screw in Pennsylvania contractor's operations.

FIG. 2. Anchor cable attached to crank and to walking beam replaces the cumbersome wooden pitman. This is possible since pitman always works in tension.

SIMPLE CHANGES IMPROVE CABLE TOOL RIG

Two easy modifications on his cable tool rigs give Pennsylvania contractor a jump on his competitors

FIG. 3. Cable attachment on walking beam is at wrist pin. Light weight of this arrangement simplifies disconnecting crank from the pitman when coming out of the hole.

ED E. HESS, a cable tool drilling contractor of Clarion, Pennsylvania, has no radio in his company car. So during his drives between rigs, he dreams up ways of cutting corners in his operations.

Most of his work is in cleaning out old gas wells around the edges of gas storage areas, and it requires working the tools where it is impractical to use the temper screw for feeding off the drilling line.

Sheave Replaces Temper Screw

Driving along in the hilly country, Ed was trying one day to figure out a way to move the bit up and down the hole without having to unclamp and clamp the temper screw. Well, the sampson post doesn't move, so why not run the drilling line back over a sheave on top of the sampson post? When another sheave was placed in the end of the walking beam (Fig. 1) and the line run over the two sheaves, replacing the temper screw, the beam could be operated giving a good throw to the bit and the tools moved up and down the hole at the driller's command.

When it was time to come out of the hole, a clamp was thrown around the drilling cable and the slack thrown off the sheaves. It was just as easy to replace the lines on the sheaves when the tools were back on bottom.

Steel Cable Replaces Pitman

Next, Eddie turned his attention to the old wooden pitmans. Since they always work in tension, why not replace them with a steel cable instead of the cumbersome beam? He found some anchor cables with clevices attached and put one over the wrist pin on the crank and threaded the pin on the outside of the walking beam through the other (Fig. 2). With this light weight, it is simple to disconnect the crank from the pitman when it is time to come out of the hole (Fig. 3).

After Ed had changed over three of his rigs, one of his competitors who was drilling an offset well remarked, "Eddie, that thing seems to work against itself!" But when he found that Ed was making nearly twice as much hole in a given time in the same formation as he, he conceded that Ed had made a couple of modifications that were definitely working for him! ★ ★

SUPPLIERS' PARADE

New Companies, Subsidiaries & Agents

BJ Service, Inc. opened a new cementing service station in Kingfisher, Oklahoma, with Chester Chandler as field supervisor.

Bucyrus-Erie Company's new distributor for Alberta and Saskatchewan, is Rig Service and Rentals Ltd., Edmonton. They will sell and service Bucyrus' complete line of spudders, servicing equipment and parts.

Halliburton Company will take over direct control of Welex, Inc., as part of major expansion into the electronics field. Welex obtains full status as a direct Halliburton subsidiary. W. J. Greer of Welex will be chairman and chief executive officer of Welex Electronics, and vice president of the Halliburton Company, with headquarters in Washington, D.C.

The Cook Heat Treating Company will open a new plant in Houston in early 1961. The plant will occupy 56,000 sq ft and is designed to be the most up-to-date metallurgical plant in the country.

A new corporation marketing non-sticking drill collars has been formed. **Engineering Enterprises, Inc.'s** product will be called No-Wall-Stick Drill Collars.

Plastic Applicators, Inc. has opened a new $250,000 Plasticap plant in Morgan City, Louisiana.

Universal Production Service, Inc., a new concern in Midland, is staffed to drill, test, complete and produce wells. The firm is headed by Harry H. Lawson, formerly of Seaboard Oil Company of Delaware.

Appointments and Promotions

Advertising Engineers Inc. — **Bernie Klein,** appointed senior vice president serving clients in Tulsa, Dallas, Ft. Worth, Houston areas.

Atlas Pipe Inc. — **Michael E. Cassidy,** sales staff, Corpus Christi, formerly with Mid-Continent Supply Company.

Baird Manufacturing Company — **Ed Lance,** Evansville, Indiana, representative.

Bethlehem Steel Company, Supply Division—**L. G. Bettis,** treasurer, succeeding **Christian Seger Jr.,** who resigned.

BJ Service, Inc.—**Austin T. Jones,** assistant sales manager, Wichita, Kansas; **John L. Buster,** technical assistant to the vice president, Fort Worth; **C. F. McMahan,** assistant to the sales manager, Fort Worth.

Black, Sivalls & Bryson, Inc.—**Samuel C. Welker,** resident and sales manager, BS&B's Swiss subsidiary, Black, Sivalls & Bryson, S.A., headquarters in Zug, Switzerland.

Byron Jackson Division, Borg-Warner Corporation—**Alexander Valchuk,** managing director of the Netherlands, succeeding **Earl M. Rees.**

Cardwell Manufacturing Co., Inc. — **Louis G. Montre,** chief engineer, with **Edward V. Hobbs,** as his assistant.

Continental-Emsco Company — **Harry P. Woodson,** galvanizing superintendent, Houston plant.

Houston Oil Field Material Company, Inc.—**Ernest E. Baccus,** sales and service representative, East Texas, formerly with D. H. Rowland, Dallas.

Hughes Tool Company—new managers are: **James R. Leach,** general product; **J. Z. Brewer,** product coordination; **A. G. Davis,** distribution inventory planning; **W. A. Kistler, Jr.,** rock bits.

Hunt Tool Company—Gulf Coast representatives: **Ray L. Sewell, T. L. Lewis; T. L. Parrish,** Houston service representative.

Halliburton Company—**J. I. Jordon,** safety manager, field and shop operations, replacing **Harry Ziegler,** who retired after 35 years of service; **Jim Pace,** shop safety supervisor, Duncan.

Johnston Testers, Inc.—**B. R. Dixon,** vice president-operations and elected to the board of directors.

Jones & Laughlin Supply Division—**J. A. Tucker,** chief engineer-LACT and processing equipment; district sales managers: **M. D. Hartsell,** Wichita; **J. A. Beaird,** Bartlesville; **R. A. Mercer** and **J. A. Carrigan,** city sales managers of New Orleans and Los Angeles respectively.

"Matched Tools for Unmatched Performance"

Web Wilson Sabre-Tooth Tong Dies

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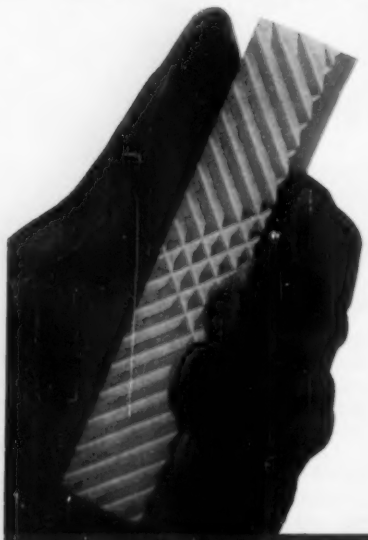

Choice of the industry, Sabre-Tooth Tong Dies are made from *triple-alloy* steel, heat treated in an advanced, carefully controlled process which adds carbon for a *hard exterior*, but leaves a tough resilient core. Angular teeth prevent deep biting, which protects the pipe. The *reversible feature* means longer die life. Corrosion is resisted by cadmium plating. Available for all sizes of tongs.

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The popular Tiger Tooth Tong Die meets the same high metallurgical standards and is cadmium plated for corrosion protection.

"Jiffy" Tong-Die Driver and Slot Conditioner with its overhanging protective shield prevents flying chips, and automatically cleans the slot for the new die.

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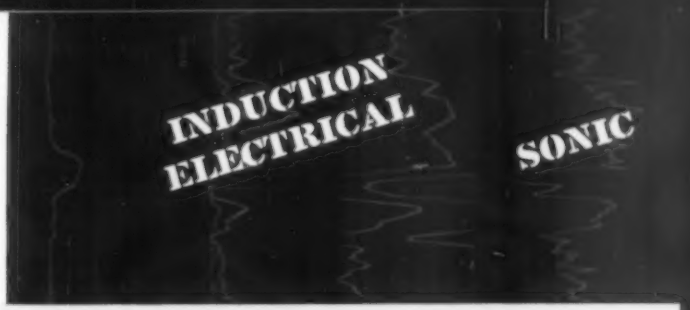

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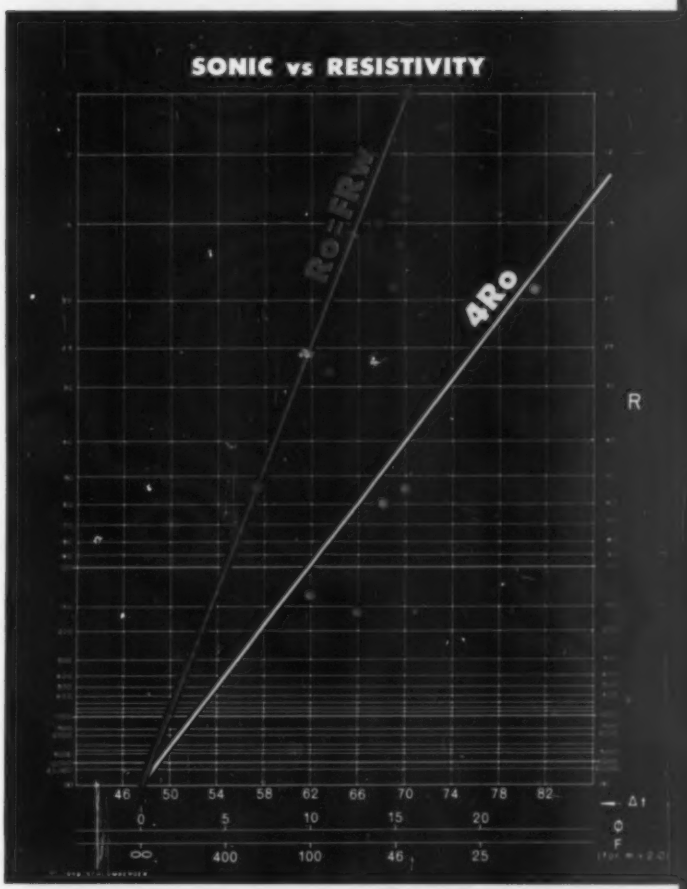

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Hagan Controlled Solubility Phosphates Stop Calcium Carbonate Scale

Many areas in West Texas have serious calcium carbonate problems. Rods and tubing become completely coated with scale, and production must be held up while the well is pulled and mechanically cleaned. Here are some case histories that show how Hagan's Controlled Solubility Phosphate, type 15-J, lowered costs by keeping production up and eliminating the expense of pulling and cleaning.

1 In the Pecos Valley area of Texas, a major oil company had a well making 65 BOPD with 61% water. When the pump froze and the well was pulled, rods and tubing were found to be coated with calcium carbonate scale. Deposits had even started on the collar.

Treatment with Hagan's 15-J was initiated, and the well was pulled forty-five days later to check on the effect. Pumping rods were perfectly clean and 85% of the scale had been removed from the tubing. The 15-J had not only prevented further deposits, but had also removed most of the accumulation. This operator is very satisfied with his savings.

2 This well in west central Texas was producing 60 BOPD and 15 BWPD. Due to accumulations of calcium carbonate scale, it was being pulled every 23 days at a cost of $150.00 to $200.00. To eliminate this cost, Hagan 15-J, Controlled Solubility Phosphate was tried. The 15-J was applied downhole, with an initial charge of about 15 pounds, and an additional charge of two to three pounds every two weeks. Since the start of treatment 14 months ago, there has been no need to pull this well—a very substantial saving for the operator.

3 Heater treaters in this area became so clogged with calcium carbonate scale that shutdown and cleaning was necessary every 30 days. Since every shutdown cost in excess of $60, the major oil company operating the field looked for a solution. They found it in 15-J. Treatment was initially maintained for a 90-day test period. At the end of this time, complete inspection of the heater treaters showed only traces of scale. Treatment with 15-J was continued and another inspection after 6 months found spotlessly clean firetubes with no indication of scale.

For information on how Hagan's complete line of Controlled Solubility Phosphates can help you, write or phone the address below.

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MACCO Oil Tool Company — **W. F. Krause Jr.,** chief petroleum engineer, formerly with Baash-Ross Tool Company.

Pan Geo Atlas Corporation, a subsidiary of the Chemetron Corporation— **E. P. Boynton,** vice president.

Parkersburg Rig & Reel Company— **Meredith Roberts** and **Willi Stahl,** export sales manager and assistant manager, respectively.

Pipe Inspectors Division of Plastic Applicators, Inc. — **Louis J. Wernert,** sales representative, Odessa.

Rockwell Manufacturing Company, Meter and Valve Division—**James Dvoracek,** mid-western regional manager; **James H. Sells,** district manager, Houston area.

Schlumberger Well Surveying Corporation—reassigned division managers: **C. A. Rosenthal,** Texas Gulf Coast; **I. L. Roberts,** Louisiana Gulf Coast; and **Adam Perez,** Southern Rocky Mountains. Sales engineers: **W. A. Montgomery,** Fort Morgan, Colorado; **W. F. Stephen,** Kimball, Nebraska; **B. E. Davis,** Enid, Oklahoma; **W. B. Jackson,** Houston.

Welex, Inc. — new district managers: **Jerry Cahill,** Tyler, Texas; **Ray Evans,** Fort Worth.

General News

H. John Eastman, who retired from Eastman Well Survey Company, which he founded, has acquired a 20% interest in Eastman International Company GmbH, Hanover. It is expected that this company will be entrusted with the exclusive execution of Eastman transactions in Europe.

Atlas Pipe Inc., a division of Atlas Bradford Company, moved its Corpus Christi shops and yard to a larger site, 15 acres, on Up River road. A new office building is also on the site.

A sales manager's job is always an interesting one, but here's one with a real challenge. Jack Knowlton, of **Martin-Decker,** explains their new Drilloger electric recorder to Miss Stella Marquez, Miss International Beauty of 1961. And they say that business is bad all over!

DuMore

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are known throughout the oil patch for their exceptional resistance to any troublesome pumping condition. DuMore is an exceedingly hard alloy composition of chromium, cobalt, and tungsten. The metallurgical properties of this combination are comparable to tungsten carbide — the hardest metal in commercial use today. A bargain at any price, DuMore costs only a little more than regular grade assemblies, but the expense of one pulling job alone will more than pay for fitting out a pump with DuMore Balls and Seats.

Try DuMore the next time you run a pump in a troublesome, hard-to-pump well. You will be more than satisfied with the service you'll get, and you'll like saving those pulling jobs, too! If you want the "Best Ball and Seat in the Oil Patch," ask your supply store about DuMore.

"BEST PUMPS IN THE OIL PATCH"

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EXPLORATION ACTIVITIES

AUSTRALIA

Mornington Island Test Delayed by Grounding

A 6000-ft exploratory test on Mornington Island in the Gulf of Carpentaria was originally scheduled to be drilled immediately by Delhi-Taylor Oil Corporation. But due to two accidental groundings of the vessel chartered to move a drilling rig to the well location, test will be deferred until early in 1961.

Seismic and geological surface work is continuing in the Great Artesian Basin area where Delhi, Frome-Broken Hill, Pty. and Santos Ltd. have a joint venture.

NIGERIA

Tennessee Gas Nigeria Planning Exploration

Tennessee Gas Nigeria is expected to begin preliminary exploration work in that country immediately. Firm has onshore exploration rights along the coast of the Western Region between Lagos and Benin.

CALIFORNIA

Leasing of 50,000 Acres Off Santa Barbara Set

Tideland leasing in a 50,000-acre offshore area in Santa Barbara County, California, has been approved by the state's land commission. Acreage is not covered by existing oil and gas leases which lie between Elwood and Point Conception and extends seaward three nautical miles.

Lease sale could be held about January 15, 1961 and the type of bidding to be used will be cash bonus bidding.

ALASKA

Third Alaska Land Sale

Alaska's third competitive oil and gas lease sale is being held this month at Anchorage. There are 73,027 acres of offshore lands in 26 separate tracts offered, Roscoe E. Bell, Alaska's director of lands announced.

LOUISIANA

Offshore Well Yields 2 Natural Gas Completions

Two successful natural gas completions in the Louisiana Gulf Coast area, one an onshore wildcat discovery and the other an offshore step-out well confirming an earlier test, were announced by Tennessee Gas and Oil Company.

Onshore wildcat, the Luke Detraz No. 1-A tested at 4.9 MMcfd of gas, plus 39.2 bbl of condensate per million, on a 12/64-in. choke from perforations at 14,717 to 14,732 ft in the Abbeville sand series. Further tests were scheduled on the well, which is in Vermilion Parish about five miles south of Abbeville.

The offshore confirmation well, in West Cameron Block 165, tested at 2.3 MMcfd, with four bbl of condensate per million on a 12/64-in. choke from perforations at 9691 to 9697 ft. Production is from a 43-ft net sand in the Lower Cibicides opima zone of the Miocene Age.

OREGON

Test Well Near Lakeview Abandoned at 12,093 Ft

Humble Oil & Refining Company's first test on a half-million acres leased in southern Oregon and northern California has been plugged and abandoned at 12,093 ft.

Projected depth had been 12,000 ft on the dry hole, which was named the 1 Thomas Creek in Lake County.

TEXAS

Shell Stakes Second Site Offshore Near Galveston

Shell Oil Corporation has made a location for a second offshore well near Galveston, Texas. Proposed site for the second wildcat, termed the Skeet area by Shell, is situated in Federal Block OCS-236 about 30 miles from land.

As in the earlier survey of the Buccaneer site, Shell's first location offshore from Texas, high altitude rockets were used successfully as a line-of-sight guide for the three two-man survey teams taking simultaneous readings from known geodetic positions.

The two locations are 15 miles apart and on separate prospects.

Exploratory Well Planned By Conoco Near Galveston

Plans by Continental Oil Company to drill an exploratory well in the Gulf of Mexico some 40 miles off Galveston were announced. Well will be drilled in Block 349 of the Galveston area in waters 75 ft deep by a large mobile drilling platform. Depth of the well will be about 8000 ft.

Well will be the first to be drilled by Conoco on acreage it purchased at the Federal offshore lease sale held in New Orleans last February.

WISCONSIN

Drilling Operations Set On 34,000-Acre Lease

A drilling program in search of oil and gas in southeastern Sheboygan and northern Ozaukee counties will be undertaken by the Texas-Wisconsin Exploration Corporation from headquarters in Oostburg, Wisconsin.

Firm was organized for exploration by Ralph E. Davis & Associates Corporation of Houston, Texas.

Company has acquired mineral rights leases on 34,000 acres of land running in a four-mile wide stretch from the southwestern corner of Sheboygan to the east of Random Lake to a point in northern Ozaukee County.

Drilling operations are expected to start immediately.

IRAN

ENI Wildcat in Iran Waters Has 3500-Bpd Potential

Enrico Mattei, Italy's ENI director, has confirmed that their wildcat discovery in Iranian waters is commercial and that it will be capable of producing about 3500 bbl per day. Previous reports stated that the well produced 93 bbl hourly in tests of Asmari limestone at 6927 to 7380-ft, indicating that there is a potential of some 2230 bpd from that formation.

ARCTIC CIRCLE

Shallow Drilling Planned On 2,700,000-Acre Block

Atlantic Refining Company will begin drilling operations immediately on their 2,700,000-acre Glacier Block along the Mackenzie River above the Arctic Circle.

Four shallow wells exploring for oil and determining the value of surface geological surveys and seismic work conducted last year will commence as soon as the winter freeze sets in. When muskeg surface of the land has frozen, it will support heavy equipment and vehicles.

BOLIVIA

Discovery Oil Well Flows 325 Bpd at 5850 Ft

Gulf Oil Corporation announced that it has struck oil in Bolivia after four years of exploratory drilling.

The discovery well was brought in about 30 miles northwest of the city of Santa Cruz, on its "zone 1" acreage in the South American nation. The dis-

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covery well flowed 325 bbl a day of 50 deg gravity oil from perforations at 5850 ft. A lower interval also tested oil of similar gravity and other shallower prospects have not yet been evaluated.

Gulf has about 1,020,000 acres under concession in the general area of its new discovery well.

UTAH

Exploration Program Begins With Survey in Northeast

A location has been surveyed on a block of acreage in northeastern Utah for the first test well under a joint exploration program of Southern Union Gas Company and Pacific Lighting Corporation. Companies plan to develop gas reserves in the Southwest and Rocky Mountain regions.

Southern Union Production Company and Pacific Natural Gas Exploration Company, a newly-formed subsidiary, will carry out the program. Blocks of acreage located within 100 miles of the interstate pipeline systems serving the Southern California market will be acquired by Southern Union. Then Pacific will provide the funds for drilling a minimum of ten exploratory tests per year.

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TIME CYCLE CONTROLLER

for fully automatic time cycle control of injection gas

The Camco-King Time Cycle Controller provides fully automatic time cycle and pressure control of intermittent gas injection operations on offshore or other unattended installations. Pneumatic operation virtually eliminates any possibility of mechanical failure. Camco-King Controllers can be used on any installation requiring automatic opening and closing of motor valves on a predetermined time schedule.

A bellows-activated shut-off valve is available as optional equipment for tubing or casing pressure control. The Camco-King Controller is operated with ordinary injection gas pressure and can be mounted on any type Camco motor valve. By simply reversing a check valve in the line and mounting the controller on the correct type valve, control action can be changed from direct to indirect.

For more information, contact your Camco representative or write:

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NEW MEXICO

Deep Venture Finds Big Pay in Lea County

Union Oil Company of California has opened a new Wolfcamp zone oil field in Lea County, New Mexico, at its No. 1-33 Union-State in NW of 33-15s-32e, at 7 miles northeast of Maljamar and five miles west of the South Saunders field.

Wildcat was drilled to 13,502 ft, and casing perforated at 9952 to 9980 ft. On completion test the well flowed 1224 bbl of oil a day with gas-oil ratio of 1550 to 1 on a 30/64-in. choke.

In San Juan County, Tennessee Gas Transmission Company has a new pay discovery in the Kutz field at its No. 1-A Valdex, in SW NE SE of 24-29n-11w. Dakota intervals at 6107 to 6282 ft made 5,000,000 cu ft of gas daily through a ¾-in. choke with calculated open flow of 6,000,000 cu ft daily.

LIBYA

Dahra Field Well Flows 11,500 bpd During Test

An oil well in the Dahra field of Libya which flow-tested at the rate of 11,500 bpd has been announced by Oasis Oil Company. The F-9 well, located in Concession 32, is the largest yet brought in by the group and is the third largest ever completed in Libya.

Flowing 40-degree gravity crude, the well extends the Dahra field 2¼ miles southeast from the group's F-2 well, which has tested at the rate of 8000 bpd. Crude from the new well flowed through perforations from 3066 ft to 3106 ft and 3120 to 3130 ft.

GUATEMALA

Delhi Guatemala Named El Peten Group Operator

Delhi Guatemala Exploration Corporation, subsidiary of Delhi-Taylor Oil Corporation, has been approved by the Guatemalan government as operator for the El Peten group which is conducting exploratory activity in Northwestern Guatemala.

Group has concession in two areas comprising some 1,337,000 acres. Only geological and geophysical explorations have been conducted thus far.

New Device May Aid Underwater Completions

A new development with possible applications for underwater completions is a five-mile length of silver-plated electrical cable which will soon enable naval oceanographers for the first time to conduct scientific studies of ocean depths for prolonged periods.

The cable, specially designed and produced for greater conductivity, is the heart line of an awesome-looking remote-controlled underwater device with the body of a Marine Corps "Ontos" tank, an electro-mechanical arm which synthesizes the motions of its human counterpart, and four "eyes" in the form of television cameras which can transmit to a monitor screen on shore a three-dimensional picture equal in clarity to a good home movie.

Uses for the manless undersea vehicle — called RUM for remote underwater manipulator — include observations of the sea floor, the collection of samples and specimens from the depths, and the assembly and installation of deep-bottom mounted instrumentation in the ocean. It has recently undergone tests off the California coast.

RUM can operate at depths down to 20,000 ft, and it can crawl along the ocean floor at about three miles an hour. It can maneuver and operate on a 60-percent grade, and it is capable of climbing verticle objects 12-in. in height. It soon may be equipped with an "underwater helicopter" with rotor blades, which will permit it to raise or lower itself in the water, move sideways, hover like a helicopter, or just "float".

A single operator, manning a control board ashore and watching the underwater progress of the strange new "fish" on a monitoring television screen, can send control impulses through the silver-plated cable to any part of the device with the flip of a switch or the turn of a lever.

Device was developed by the University of California's Scripps Institute of Oceanography.

Rubber Sheeting Lines 7½ Acre Salt Water Pit

Unique new use for butyl rubber sheeting is the lining of a 7½ acre salt-water pit at a Mobil Oil Company installation in Hull, Texas. Mobil uses the pit for storage of a saturated solution of salt water — the ballast for raising liquid petroleum gases in nearby underground storage facilities.

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ECONOMY • CLEARANCE
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RUNNING TOUR with MEN in the INDUSTRY

William R. Haynes, former president of Mikton Oil Company and vice president of Fifteen Oil Company (Houston), is president of a newly-formed corporation, Diversified Petroleum Enterprises, Inc. Purpose of the new firm is to purchase various types of compressing, treating, separating and other equipment designed and fabricated to the producer's specifications . . . then lease the equipment to the producer. Idea is to reduce the capital outlay by the producer and to permit him to expense the rental charges for tax purposes. **Dixon H. Cain,** former president of Fifteen Oil Company, is vice president of Diversified and **Harry H. Hudson,** former secretary-treasurer of Fifteen Oil Company, is secretary-treasurer.

At the 31 annual membership meeting of the Independent Petroleum Association of America, held October 24-25 in Dallas, **Alvin C. Hope** was elected president. New members are: **Reid Brazell,** Alma, Michigan; **Harold Decker,** Houston; **George P. Ellison,** Owensboro, Kentucky; **James P. Evans Jr.,** Jackson, Mississippi; **John E. Howell,** Houston, Texas; **Radcliffe Killam,** Laredo, Texas; **James H. Nobles Jr.,** El Dorado, Arkansas.

A. C. Hope

E. L. Petree

E. L. Petree has been named production coordinator for Gulf Oil Corporation's domestic production operations headquartering in Houston. He will report directly to **H. F. Beardmore,** who was recently elected vice president in charge of domestic production operations. **Eugene Hosford** will succeed Beardmore as manager of the Houston production district.

Pacific Natural Gas Exploration Company, newly-formed subsidiary of Pacific Lighting Corporation, announced its officers: **Grove Lawrence,** president; **Stuart T. Peeler,** vice president-secretary; **Harry L. Bosshard,** treasurer-assistant secretary; and **Thomas A. Johnson Jr.,** field manager.

Petroleum Property Management, Inc. of Dallas has elected **J. W. Hinckley,** vice president.

William C. McCammon was named vice president, supply and transportation, for Standard Oil Company of California, Western Operations, Inc.

James C. Storm has been elected president of Tidelands Drilling Company, wholly-owned subsidiary of Diversa, Inc.

California Research Corporation promoted **T. L. Russell** to group supervisor, drilling research and offshore problems, La Habra Laboratory.

Texaco Inc. has announced appointment of **Turner L. Kunkel** as Los Angeles producing division manager, succeeding **J. Harold Puls,** who retires January 1 after 35 years' service.

Hugh J. Davis is a new division landman at Texas Gas Exploration Foreign C.A., supervising drilling agreements and maintenance of gas-oil leases in Calgary.

Dudley Tower has been made president of the Union Oil Company of California, replacing **Reese H. Taylor.**

Earle F. Taylor, Glen R. Neighbors and **Stewart H. Folk** have formed a consulting firm to be known as Taylor and Associates, Inc., with offices in Houston. They plan to specialize in consulting work in foreign countries and Alaska.

Gus Athanas moves to Calgary as superintendent in charge of production operations for Pan American Petroleum Corporation. **J. D. Burns** succeeds Athanas as Pembina area superintendent.

W. A. McElhannon has been named senior supervising engineer in the cracking and light ends division of Humble Oil & Refining Company's Baytown division. **Oscar F. Yates,** senior petroleum engineer, moves to Hawkins, Texas.

Jack Morris has been transferred from Denver to Casper, Wyoming, as district exploration superintendent for Tennessee Gas & Oil Company.

E. G. Jackson Jr., has been transferred from the Corpus Christi office of Shell Oil Company to Houston as exploitation engineer. **G. E. Klein** moves to Midland in the same capacity.

William W. Walmsley is the new manager of Sun Oil Company's Rocky Mountain division, succeeding **Philip S. Justice,** who has been appointed special assistant to **Jno. G. Pew,** senior vice president in charge of production.

James B. Smith is Continental Oil Company's new research geochemist in the exploration-research department at Ponca City, Oklahoma. **A. R. Field** has been named assistant district superintendent with Cherokee Pipe Line Company, an affiliate of Continental in Wood River, Illinois.

John H. Williams, chief engineer at California Oil Company since 1947, retired after 34 years' service.

Frazier M. Stewart has been elected second vice president of the commercial banking department of Continental Illinois National Bank and Trust Company of Chicago.

Continental Oil Company announced key executive appointments in their foreign and exploration departments: **J. S. Royds,** vice president-exploration manager, foreign exploration and production, headquarters in New York City; **W. O. Ham Jr.,** general manager-domestic exploration, succeeding Royds in Houston; **Harold R. Prescott,** assistant manager-domestic exploration, Houston.

Several changes were announced by King-Stevenson Oil Company, Inc.; **Roger M. Matson,** chief geologist; **Owen Bennett,** staff geologist; **S. M. Anderson, Jr.,** manager-Southwestern division; **Hobson Mann,** staff engineer, drilling engineer.

Tyrus C. Stewart was named traffic manager of Lion Oil Company, a division of Monsanto Chemical Company, replacing **Percy G. Anderson,** who retires after 20 years' service.

C. H. Calvert Jr., joined the gas reserves and availability division of Northern Natural Gas Company as reserve engineer.

Helmerich & Payne, Inc. paid tribute to its senior employees at a recent club meeting. **W. H. Helmerich,** (right) president of the company, presented service pins and service awards to 12 employees. **L. M. Wall** (left) received the principal award honoring his 30 years' service. He started as a roughneck in 1930 and is currently a toolpusher on a company rig in Southern Oklahoma.

GOOD MEN GOOD TOOLS

Dependable remedial and stimulation service demands both. Baker offers both.

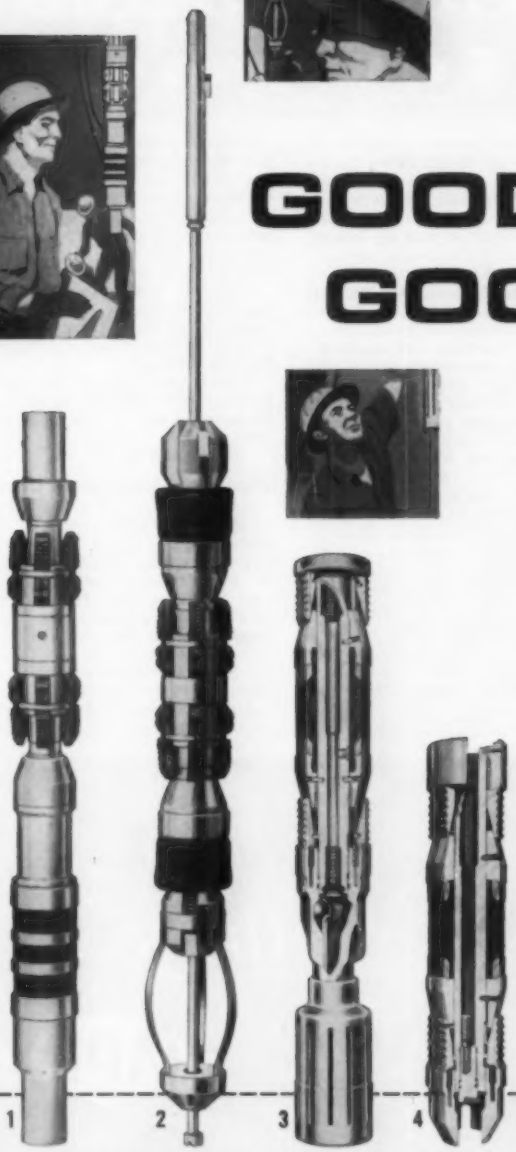
YOU ARE LOOKING at four of the most respected well-service tools in the industry. They command respect because their performance is consistent and reliable. They have proved themselves in thousands of critical downhole operations.

Simplicity is important in service tools. A simple tool is a reliable tool—and it is easier to control when it's in the well. Simplicity of design is one important reason for the success of Baker service tools.

YOUR BAKER SERVICEMAN lives and works in your area—and he knows the well-service problems of your area.

His local knowledge is vital. It helps keep him—and you—out of unforeseen situations. It helps him sense trouble before it starts. It guides him—and you—when you get into something you couldn't anticipate.

A Baker Serviceman does his work with confidence and authority. He knows his area, and he knows Baker tools. He's a tool specialist. Baker tools are his *only* business. He's a good man to call for your next remedial or stimulation job.



Baker provides the right tool (or tools) and accessories for any remedial or stimulation job.

1 Baker Retrievable Full-bore Cementer (Product 410) is an important squeeze cementing, fracturing, acidizing, testing packer. It is teamed with **2** Baker Retrievable Bridge Plug (Product 677-C) in straddle operations, either single-zone or selective multiple-zone. Cementer and Plug together can straddle a virtually unlimited distance. And any number of zones can be treated in one round trip. **3** Baker Drillable Cement Retainer (Product 400) sets the industry standard for dependable high-performance squeeze cementing. **4** Baker Drillable Wire Line Bridge Plug (Product 400-N) is the industry's most available and most reliable bridge plug.

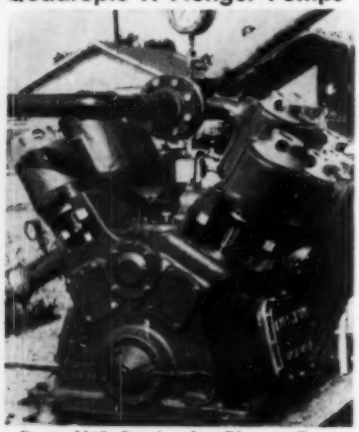
BAKER REMEDIAL AND STIMULATION TOOLS

BAKER OIL TOOLS, INC. HOUSTON / LOS ANGELES / NEW YORK

It's New

Drilling-Producing Equipment

Quadruple X Plunger Pumps



Barry V60 Quadruplex Plunger Pumps are now available from 150 to 1250 hp and 100 to 1300 gpm in five frames and sizes, with eight models trimmed for any service.

Revolutionary suction and packing design handles fluids without pressurized suction. Fluid being pumped into lower valves never stops or changes flow direction.

Non-adjustable packing with rigid metal body holding the lip of the packing in place is designed so packing cannot flow.

Unique crankshaft assembly permits two extra bearings. These shorter bearing spans reduce possibility of shaft distortion.

Power frame of one-piece cast construction with heavy cross-bracing gives rigidity and strength. V-type construction gives compactness and reduces weight. Direct drive with flexible gear ratio also saves space without sacrificing rigidity.

Individual valve pots containing cylinder heads and threaded valve covers provide ease of access for repair.

Pumps will handle fluids of viscosity up to 30,000 Saybolt Universal Seconds at normal operating speed and will handle light hydrocarbon fluids at a higher volumetric efficiency. *Barry Pump Company.*

Circle number (1) on reply card.

Gas Desulfurizing Unit

A new automatic gas desulfurizing unit has been developed which provides trouble-free operation and economical maintenance.

Unit is of the amine-type and is called the "Sweet-A-Mine." It removes hydrogen sulfide and carbon dioxide from gas by absorbing the acid gases in a solution of monoethanolamine in water. The resulting sour amine solution is regenerated for re-use. The plant is in two assemblies, absorber and regenerator.

The unit can operate unattended, requiring only supply gas to actuate pneumatic valves and fuel gas for the reboiler. It will operate efficiently under all climatic conditions.

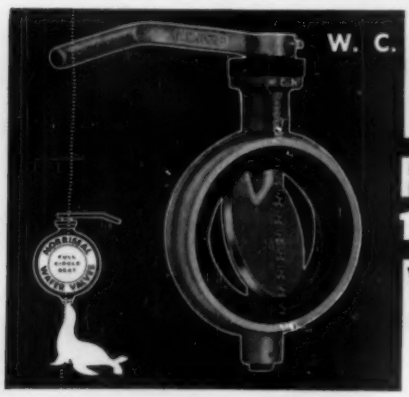
Unit is available for any gas capacity, starting with 500 Mcf per day. *Maloney-Crawford Tank and Manufacturing Company.*

Circle number (2) on reply card.

Mobile Telephone Unit

Electronic device manufactured by Carter Electronics allows operator of a private two-way radio to talk from a mobile unit into any public telephone service—local or long distance. Known as Carterfone, the device is entirely automatic — the speaker's voice places the base station transmitter on the air. Unit doesn't require a vehicle installation as one unit at the base control station serves every mobile unit on the system.

Unit is completely transistorized and

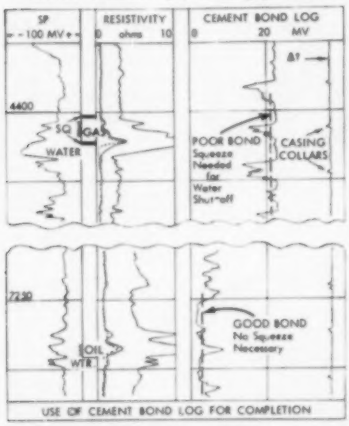


NORRIS
Field Tested and Approved
150 psi working pressure
WRITE FOR NEW VALVE BULLETIN
P. O. Box 1739, Tulsa
VALVES

does not require switching off and on from transmitting to receiving. In effect, the unit places a telephone in each two-way radio equipped vehicle.

This is how it's done: A telephone contact is established between the operator of a base station and any party with available public telephone service. The telephone handset at the base station is then placed in the specially-designed cradle. From then on broadcasting and receiving operations of the station are entirely automatic. *Carter Electronics Corporation.*

Circle number (3) on reply card.



Cement Bond Logging

Schlumberger Cement Bond Log presents a recording of the quality of the casing cement job. Operation of the new service is based on the fact that the energy of a sonic pulse transmitted along a casing diminishes rapidly where the casing is bonded to material such as hardened cement which has a sonic velocity much lower than that of the casing.

By pointing to intervals where bonding is incomplete, even lacking entirely, the log indicates channeling and gaps in the cement column which require squeezing. At the same time, by denoting effectively cemented zones, the log saves the cost of many squeeze jobs formerly run to insure shut-off before testing.

Cement Bond log can be run simultaneously with Gamma Ray Log for correlation with open hole logs. *Schlumberger Well Surveying Corporation.*

Circle number (4) on reply card.

Fracture Initiation Tool

Triple Frac-Notch Cutter which operates on an electric wire line makes three separate notch cuts simultaneously on one run of the tool. Developed by McCullough Tool, each notch cuts through casing and cement then cuts and fractures up to 15-in. into surrounding formation.

These notches are cut on a horizontal plane at the same depth in the well. A strong, solid segment of uncut casing is left between each notch, but the uncut formation between these notches is fractured during the cutting process. This gives the effect of full-circle fracturing.

Explosive power of cutting process notches into formation and also fractures formation for some distance beyond the face of the actual cut even before application of hydraulic pressure. Broken formation requires lower hydraulic fracturing pressure and formation usually takes a greater amount of propping material at a faster rate. A larger area of formation is more effectively fractured, also.

Usually run on same service unit set-up for collar and radioactivity logging, cutter is available for use in 2-in., 2½-in., 3-in., and 3½-in. tubing and in casing ranging from 4½-in. OD through 7-in. OD. *McCullough Tool Company.*

Circle number (5) on reply card.

Power Casing Tong

A power casing tong manufactured by Lamb is available in sizes ranging from 4-in. through 13 4/8-in. It has a compact 32-in. handle length with a convenient fold-down hanger.

Tong weighs 925 lb and operates at 100 rpm in high gear, 25 rpm in low gear, forward or reverse.

Torque delivered is 3750 ft-lb in high, 15,000 lb in forward or reverse.

Speed can be controlled from 0 to 100 rpm, and maximum torque output can be set at any predetermined torque. Gripping action is automatic and can be reversed instantly without removing the tong from the pipe.

Contour jaw prevents slip and crimping of pipe even under maximum torque. *Lamb Casing Service.*

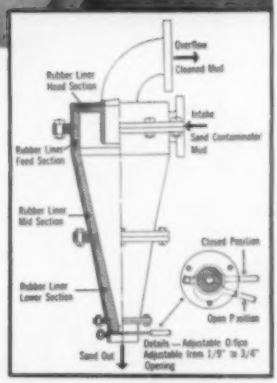
Circle number (6) on reply card.

Keep sand content of mud as low as ¼ of 1% with NEW THOMPSON DESANDER

Here's why you save with Thompson

1. Completely rubber lined 9/16" thick
2. Adjustable discharge head speeds set up
3. Discharge in desired direction for faster set up
4. Quick cleanout
5. Controls sand discharge with lever

Get the facts today!



SOLD ONLY THROUGH SUPPLY STORES

THOMPSON TOOL COMPANY
Iowa Park, Texas

Aluminum Drill String

A commercial test of a full drill string made of aluminum has been completed in a 10,000-ft DeWitt County well. Rig used was originally designed for drilling depths to 7000 ft, but lighter string permitted drilling to greater depth. A 4½-in. aluminum pipe in a 30-ft section weighs almost 200 lb less than steel.

From ⅓ to ½ less hp is needed to pull and run an aluminum string, resulting also in reduced hoisting costs. Smooth bore of extruded aluminum pipe gives improved hyuraulics, also.

Ability to bend without stress should make aluminum pipe especially suitable to directional drilling. Aluminum pipe will vary no more than ½-in. from a standard 30-ft length, making tallying of drilling depth simpler.

Steel joints are used on the aluminum drill stem, attached in a recently developed special process by Reed Roller Bit Company. *Reynolds Metals Company.*

Circle number (7) on reply card.

Continuous Gas Sampler

Continuous gas sampler for accurate determination of chemical and physical properties of gas has been developed by ARCCO Instrument. This Model M-R sampler will, during a period of seven days, accumulate at a constant rate a sample of gas to a final pressure at or near 140 psig from the sample source — the minimum pressure of which is not less than 160 psig.

Instrument has a mechanical drive and includes a pressure recorder in a single case for sample ranges up to 150 psig when required.

Gas sample is gathered in a portable container.

Instrument can be employed in any hazardous area where vapor-proof equipment is required because it needs no external source of power. *ARCCO Instrument Company, Inc.*

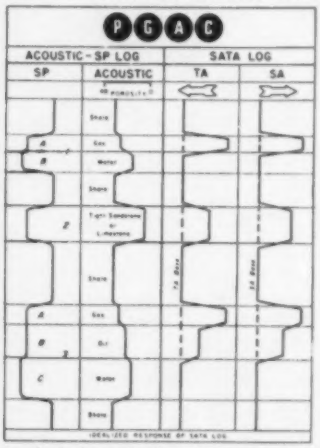
Circle number (8) on reply card.

Acoustic Logging

New Sata Log, now being run by Pan Geo Atlas, utilizes a unique application of acoustic logging.

Device logs a physical property of oil itself, using the distinct acoustic properties of hydrocarbons to distinguish between gas, oil, and water on a qualitative basis in both high and low porosity media.

Device is especially suitable in fresh water sands and reservoirs which contain



enough shale and salt water to cause low resistivity readings on electrical logs.

Log exhibits two curves—attenuation of the acoustic signal (SA) between two receivers, and the transmission amplitude (TA) of the acoustic energy at the first receiver. *Pan Geo Atlas Corporation.*

Circle number (9) on reply card.

Direct-Fired Air Heater

A packaged, direct-fired air heater designed for high combustion efficiencies and absence of impurities has been manufactured by Black, Sivalls & Bryson.

Unique UNIFLUX Fuel Reactor, a high-intensity mixer in which combustion air is brought into an annular space around a combustion chamber, forms the heart of the unit. This cools the combustion chamber and enables the fuel reactor to be constructed entirely of metal.

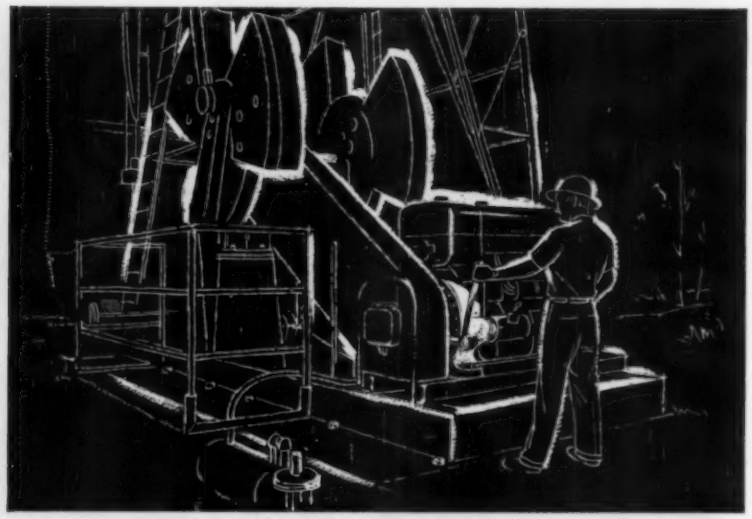
Intimate mixing of combustibles with air occurring inside this reactor results in essentially complete combustion.

Inert products of combustion leave the chamber at flame temperatures and at velocities of about 500 ft per sec. The hot gases flow into another reactor where they mix with air or gas which is to be heated. Thus no harmful carbon residues or combustibles such as aldehydes or carbon monoxide should be present in this reactor.

The fuel reactor has excellent stability through a wide range of air-to-fuel ratios, the manufacturer states, and simple, accurate controls.

Delivered unit ready for immediate operation is available in sizes ranging from 100,000 Btu per hr to 10,000,000 Btu per hr heat release. *Black, Sivalls & Bryson, Inc.*

Circle number (10) on reply card.



DEPENDABLE PUMPING
with Rockford Power Take-Offs

It's no wonder why more and more oil men specify Rockford PTO's. These maintenance-free PTO's offer higher torque capacities, better heat dissipation, less lever pressure, and positive engagement. Rockford's infinite-control adjusting ring provides longer life. Smooth and instantaneous power is transmitted from any internal combustion engine to your working oil field equipment.
Write today for illustrated brochure.

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ROCKFORD, ILLINOIS

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Borg-Warner International
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New Literature

Electric Motors

Two-page publication lists features and advantages of General Electric's new line of Tri-Clad "55" one to five hp oil field motors. Illustrated bulletin contains tables of ratings, nomenclature and dimensions of the new motors. *General Electric Company.*

Circle number (11) on reply card.

Tubingless Completions

Baker announces a new 8-page brochure which explains how their tubingless completion equipment is used for completions utilizing tubing for small diameter casing. Booklet is divided into three sections, primary cementing, remedial and stimulation, and completion and production. New line is complete, virtually paralleling the basic Baker product line. *Baker Oil Tools, Inc.*

Circle number (12) on reply card.

Low Pressure Tubing Head

Independent tubing head for medium to shallow wells with low pressures are described in four-page, two-color National Supply folder. Available with female casing connections of 5½-in. and smaller, Type K head can also be provided with 7-in. male casing connection which has a 5⅛-in. body through bore. Folder also describes Types D and G Casing Heads and Type E Tubing Head. *National Supply Company.*

Circle number (13) on reply card.

Continuous Processing

A new revision of the 16-page brochure, Continuous Processing, Bulletin No. 7004 illustrates and lists the distinguishing characteristics and applications of 55 types of continuous processing equipment manufactured by Dorr-Oliver. This includes centrifuging, thickening and clarification, filtration, pumping, water pretreatment, and complete water treatment. Pilot plant equipment is also described, with special emphasis on classification, centrifuging, filtration and fluidization. *Dorr-Oliver Inc.*

Circle number (14) on reply card.

Web Belt Slings, Alloy Chain Line

A 16-page illustrated brochure gives specifications and working load limits for company's line of alloy chain slings, rings, links and hooks. New items are latest addition to J&L's complete safety in lifting line which also includes all standard and custom wire rope; single part, cable laid and braided JalFlex slings; JalKlamp, Jalloc, and hand splices; manila and synthetic ropes; hand and power hoists; synthetic and woven wire belt slings; and other custom-engineered lifting products. Another multi-color brochure describes a complete new line of Safety-Weave synthetic web belt slings, both dacron and nylon. *Jones & Laughlin Steel Corporation.*

Circle number (15) on reply card.

Casing and Tubing Heads

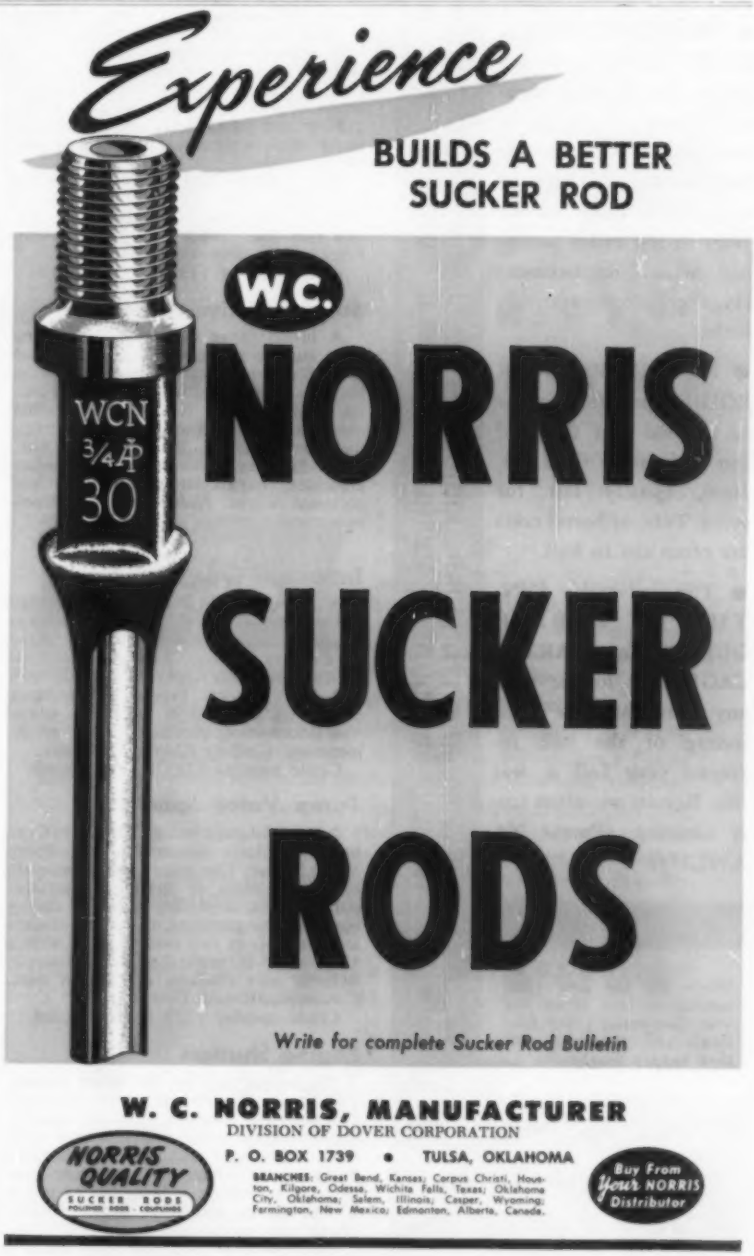
Complete information on Oil Center Tool's newest designs in forged steel independent (low pressure) casing and tubing heads is now available in a bulletin recently published. Entitled "Independent Well Head Equipment — Technical Information," the 8-page bulletin features technical descriptions, dimensions and parts charts and schematic drawings of the new O-C-T series forged steel casing heads and TH series forged steel tubing heads. Application information as well as illustrations of Christmas tree assemblies with typical combinations of O-C-T independent casing and tubing heads are included. Equipment combinations for landing and hanging dual tubing strings with the TH series of independent tubing heads also are illustrated. *Oil Center Tool Company.*

Circle number (16) on reply card.

Flexible Cushion Couplings

Two new types of Dodge Para-flex Flexible Cushion Couplings, one for high speed, high torque applications and another for attachment to flywheels of internal combustion engines, are described in a new 20-page bulletin from Dodge. Complete engineering data, photographs, dimension drawings and selection tables cover the new High Speed and Flywheel Couplings which are offered in sizes to deliver up to 47 hp per 100 rpm. The couplings have bushings to fit shafts up to 4-in. in diam. Hubs can be ordered to size to fit larger shafts, up to six-in. *Dodge Manufacturing Corporation.*

Circle number (17) on reply card.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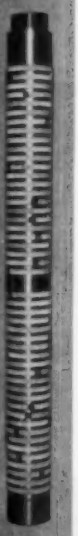

● MARTIN RUBBER & DUCK RINGS give excellent life in dirty abrasive fluids . . . high or low gravity . . . much or little water . . . shallow or deep wells. They last for years in the easier pumping wells. Replacement rings cost comparatively little.

● MARTIN PLUNGER BODIES, precision grooved, drilled and threaded (no underneath fluid passage), usually last for years. Tube or barrel costs are often cut in half.

● The replaceable SYNTHETIC RUBBER GUIDES in MARTIN CAGES last longer than any metal, and the cushioning of the ball increases your ball & seat life. Results are often truly amazing. (Patent No. 2,591,174)

Write for our new 1960 catalog or see it in the new Composite (24th Edition). All products sold thru supply companies.

JOHN N. MARTIN

Manufacturer

9 W. BRADY STREET • TULSA, OKLAHOMA

Receiver Gages

New 8-page Catalog 520 describes the complete line of dial-indicating receiver gages offered by U.S. Gauge, division of American Machine and Metals, Inc. Catalog gives specifications for both the bourdon tube and diaphragm-actuated types. It also contains information on materials, dials, ranges, and case styles and sizes. Tables give helpful selection facts and ordering is simplified with a fill-in ordering guide. Various models are illustrated with photographs of gages and movements. *United States Gauge, division of American Machine and Metals, Inc.*

Circle number (18) on reply card.

Sub-Surface Pumps For Slim-Hole Completions

Harbison-Fischer has published an illustrated bulletin on its line of Little Squirt sub-surface pumps for slim-hole completions using 1¼ or 1½-in. tubing. Literature contains illustrations of each complete pump assembly, alternate plungers, and parts and accessories.

Four rod pump sizes and five tubing pump sizes, with metal or cup plungers, are available.

Also available are seating nipples for rod pumps, and for 1¼ and 1½-in. tubing with standard API threads or special slim-hole tubing threads. *Harbison-Fischer Manufacturing Company.*

Circle number (19) on reply card.

Surface Active Agents

A broad range of cationic and nonionic surface active agents, ranging from fatty-nitrogen derivatives to polyether alcohols are described in a four-page booklet available from Nalco. Among other chemicals discussed are fatty imidazoline diamines, fatty amidomonoamines, fatty amidodiamines, quaternary ammonium chlorides, oxyalkylation products, and colloidal silicas. *Nalco Chemical Company.*

Circle number (20) on reply card.

Induction-Type Motors

A new oil field bulletin on Century Polyphase Squirrel Cage induction type motors, from 1 to 150 hp has been issued by Century Electric. Four-page oil field bulletin discusses types SC, SCH, SCS and SCT motors. Typical performance curves are included in bulletin, application information, standard ratings and dimensions. *Century Electric Company.*

Circle number (21) on reply card.

Pump Valve Spacer

A new two-page bulletin describes Continental-Emsco's Green Triangle Pump Valve Spacer. The unit is said to simplify bumping bottom or spacing subsurface-pump valves. Replacing standard carrier bars on unit pumpers, the valve spacers are available in two models, each with a 12-in. or 18-in. vertical adjustment screw. Bulletin also contains application data. *Continental-Emsco Company.*

Circle number (22) on reply card.

Engine Shutters

Use of shutters for stationary engines and trucks to increase engine efficiency and decrease operating costs is reported in a four-page bulletin. It tells how shutter is automatically adjusted by a patented thermomotor which gives absolute temperature control to within plus or minus 2 deg, the manufacturer states. *Dunlap Manufacturing Company.*

Circle number (23) on reply card.

KLAMPON

Thread Protector

The Klampon Thread Protector is a neoprene clamping device which provides maximum protection to the threads of all popular sizes and types of oil well casing. This proven device is the most versatile and well engineered casing thread protector available.

Outstanding Features:

- Long life — minimum maintenance.
- One protector operates on *all* popular threads (API, Exline, Hydril, & Buttress).
- No wrenches, compressed air, or auxiliary equipment required.
- A quick adjustment of tension nut allows rapid change from one type pipe thread to another. (No plugs, liners, etc. necessary.)

For rental throughout the U. S. contact:

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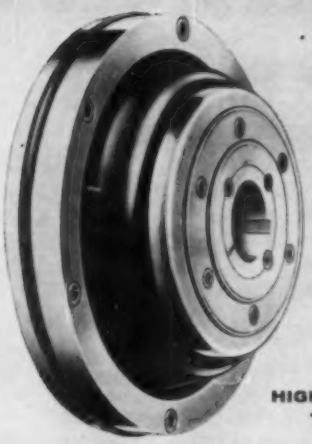
Lafayette, La. CE 5-5588

Limited distributorships now available;

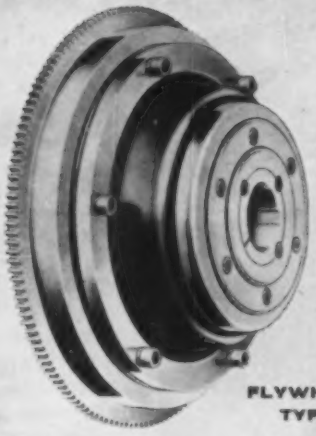
write **Lamb Rental Tools, Inc.**

For California rentals and Foreign sales contact home office.

KLAMPON CORPORATION



HIGH SPEED TYPE



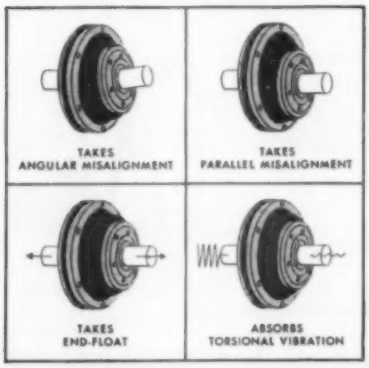
FLYWHEEL TYPE

NOW! THE COUPLING WITH THE 4-WAY FLEX

IN TWO NEW TYPES — HIGH SPEED AND FLYWHEEL

STANDARD TYPE

THE 4-WAY FLEX OF PARA-FLEX



DODGE **Para-flex**

Industry asked for this—and here it is! Dodge Para-flex, the unique coupling that swallows up misalignment, is now available for high speed applications, and for high torque at either high or low speed.

The new Dodge High Speed Para-flex is specially designed for operation with motors and internal combustion engines that turn up to 5230 rpm.

The new Flywheel Para-flex, with the same capabilities, has a flexing element that bolts directly to the flywheel of internal combustion engines.

Like the Standard Type (with capacities up to 2000 hp at 1080 rpm) these new Para-flex Couplings feature a modern, tire-like flexing element that handles angular and parallel misalignment, end-float (or any combination) and absorbs torsional vibration. The amazing performance of Para-flex Couplings is a matter of record in thousands of installations.

Ask your Dodge Distributor—or write us for new technical bulletin.

DODGE MANUFACTURING CORPORATION
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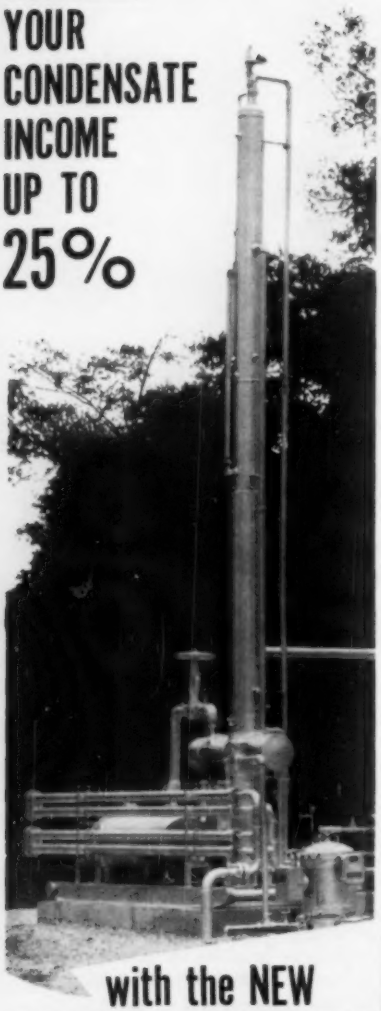

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COMMENTS ON . . .

TWO-PHASE FLOW THROUGH POROUS MEDIA

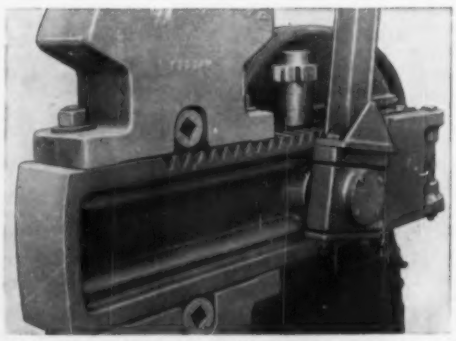
A. S. ODEH
Mobil Oil Company de Venezuela, Caracas, Venezuela

TWO MAJOR PROBLEMS encountered by investigators dealing with two-phase flow in porous media are: (1) measurement of saturation by electric resistivity, and (2) the discrepancy between experimentally determined and theoretically calculated recoveries by waterflood in high oil-water viscosity ratio systems. Solutions based on recent results are offered for consideration.

Saturation Determination

An ideal method of measuring saturation in two-phase flow should combine rapidity with inexpensive experimental set-up. The electric resistivity method would seem to combine both, but unsatisfactory results have been encountered.

Yuster and Henderson[1] and, recently, Fried[2] employed this method to determine brine and oil saturation flowing through a core sample but abandoned it as unsatisfactory due to the unrepeatability of results. In their work they used two gold-plated electrodes



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which were placed in diametrically opposite positions at the test sample surface and held by a plastic sheath. Two holes were tapped through the plastic sheath to the electrodes and two screws inserted into the holes to form contact between the electrodes and a resistivity bridge.

Recently the writer employed the same method and encountered the same difficulty.[3] Upon careful investigation the difficulty was traced to the fact that the plastic which was under tension relaxed with time, causing a variable contact between the screws and electrodes. It was also found that tightening the screws gave different resistivity readings.

To eliminate this source of error, as well as the existence of contact resistance between electrodes and core sample, the following experimental technique was devised.

Two rectangular scratches were made on diametrically opposite surfaces of the core. These scratches, ½ in. long, ¼ in. wide, and 1/16 in. deep, were filled with Silene EF, a diatomaceous earth powder, to provide a good contact between electrodes and core sample. Electrodes were made of gold-plated shimstock onto which a copper wire was soldered. They were placed in direct contact with the silene. The test sample was then mounted in lucite by compression molding. Two incisions were made on the lucite above the electrodes, and the ends of the copper wires which were soldered on the electrodes were exposed. This provided a permanent contact between the electrodes and the resistivity bridge.

This technique gave reliable and repeatable resistivity readings as a function of saturation.

Water Flood Recovery Calculations

One of the well-known formulas used to predict recovery by waterflooding is the fractional flow formula. Fried[2] conducted extensive experimental work on the effect of oil viscosity on the recovery of oil by waterflooding. He compared experimentally determined results with theoretically calculated results using the fractional flow formula.

Fried found that agreement was good throughout most of the viscosity range examined, but that at higher viscosities ($\mu_o = 100$ or more), departure of experimental values from theoretical values was evident. Experimental values gave higher oil recovery than

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theoretical values. Fried in all his calculations used one relative permeability curve that was run on the core under test.

Fried attributes this departure to the "fact that, with increasing viscosities, the theoretical oil saturation at breakthrough would eventually become asymptotic to the initial oil content of the core," the inference being that no oil would be displaced before brine would begin to flow, even though the brine phase is discontinuous at the initial saturation conditions.

This writer would like to advance a different reason for the discrepancy. In recent work[3,4] the writer found that relative permeability is not a unique function of saturation, but that it is a function of oil-water viscosity ratio. For high oil-water viscosity ratio (80 or above) and for cores of specific permeability less than one darcy, the effect of viscosity ratio on relative permeability cannot be neglected. Oil relative permeability is higher than obtained in low oil-water viscosity ratio.

If this fact is kept in mind, it is easily seen that the theoretical values of oil recovery as obtained by Fried are lower than they should be simply because he used a relative permeability curve which was not run on the high viscous oil, giving him lower values for the relative oil permeabilities. If relative permeability curves that take into account the effect of viscosity ratio are used in his calculations, agreement between experimental and theoretical values at high oil-water viscosity ratio will be as good as agreement at lower oil-water viscosity ratio.

Finally, the writer would like to emphasize that use of conventional relative permeability curves run on oil of low viscosity in calculations involving oil of high viscosity could lead to an appreciable error. This is of considerable significance due to the large quantity of very viscous oil that is produced at present in different parts of the world.

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1. Henderson, J. H. and Yuster, S. T. "Relative Permeability Studies," *Producers Monthly* (1948), 12, 13-20.
2. Fried, A. N. "Effect of Oil Viscosity on the Recovery of Oil by Water Flooding" Bureau of Mines, Report of Investigation 5115, March 1955.
3. Odeh, A. S. "Effect of Viscosity Ratio on Relative Permeability," Dissertation University of California, Los Angeles, California.
4. Odeh, A. S. "Effect of Viscosity Ratio On Relative Permeability," *Journal of Petroleum Technology*, December 1959.

★ ★ ★

IN NEXT MONTH'S ISSUE . . .

. . . we'll start the new year with a quick look back at this year and an extended look at what's to come. We've invited leaders in several phases of the drilling and producing industries to give us their ideas about what to expect. Although the predicting business can be fairly uncertain, we are sure of one thing . . . that is that we hope 1961 will be the most successful and satisfying year you've ever had.

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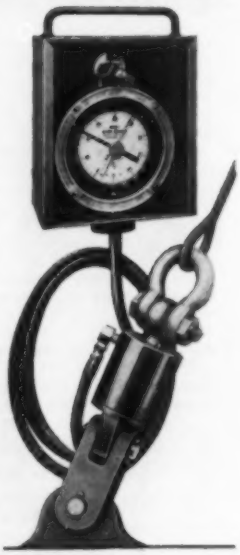

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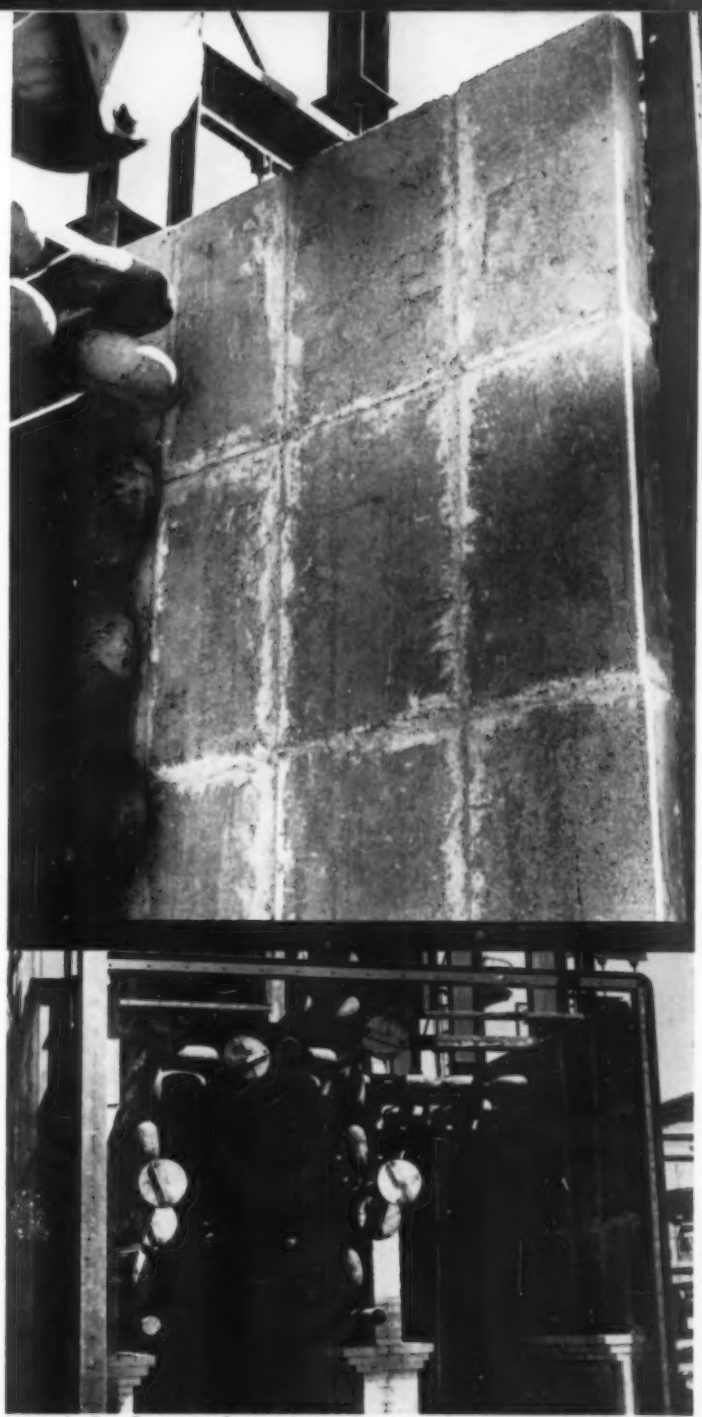

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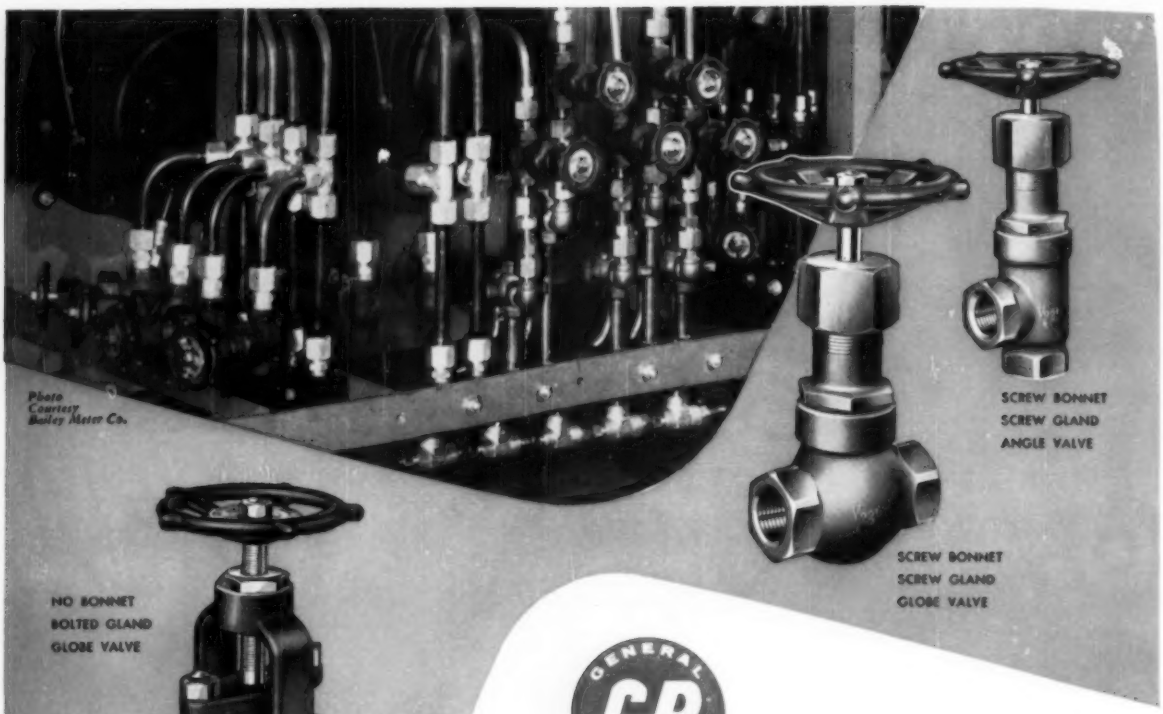

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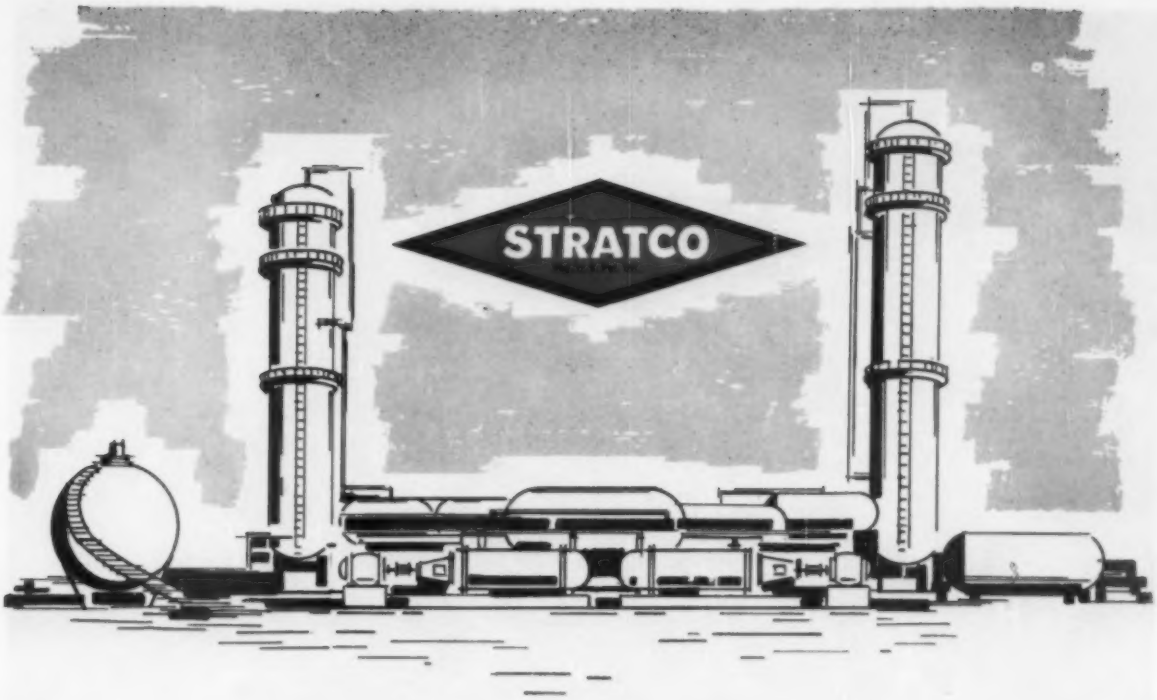

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Stratco's extensive alkylation experience in the design of this type plant is available to refiners without charge. Through the use of electronic computation various design cases can be quickly screened and optimum arrangements can be developed.

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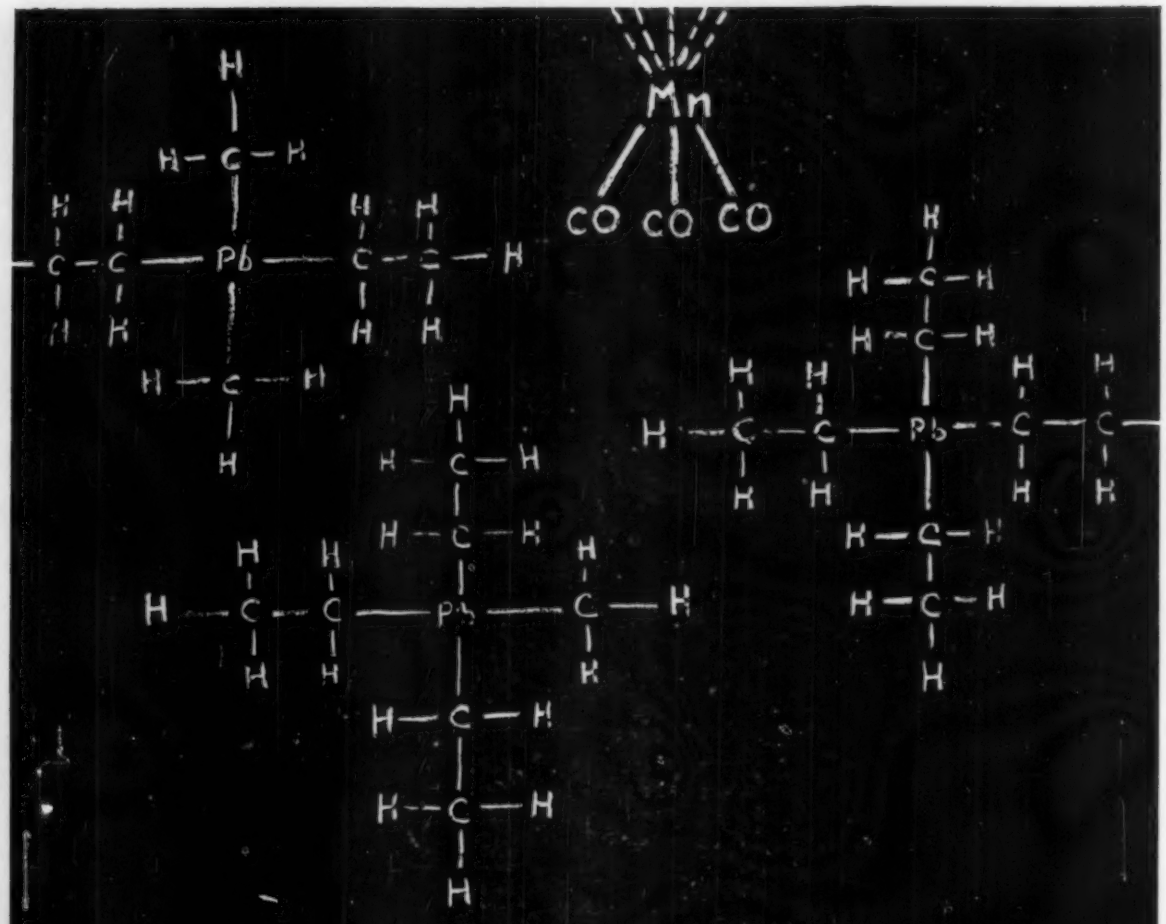

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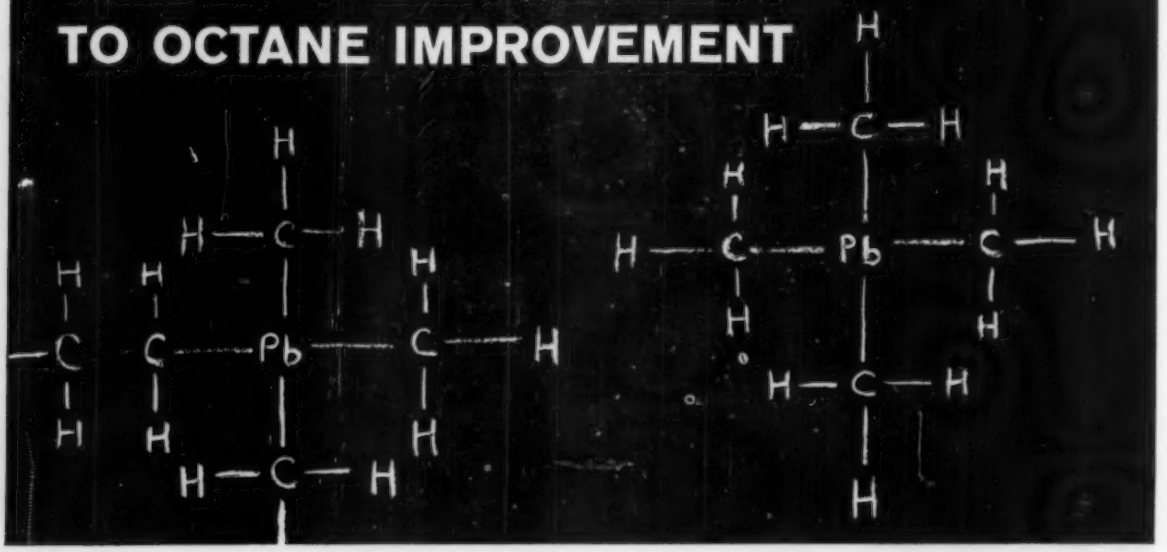

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RECENT DEVELOPMENTS in antiknock compounds have opened new areas for the refiner to consider. Just as raising the allowable limit of TEL concentration provided more latitude, new antiknocks are now available which permit even greater flexibility.

Bonus from TEL

One of the most important developments in the use of TEL came about during 1959—extending the limit to 4 ml per gallon. As a result, the average premium gasoline refined today can be increased from current levels by one and a half Research octane numbers through TEL alone. Similarly the Motor octane number gain is almost two numbers greater. Furthermore, the Road octane gain from TEL is greater than is indicated by either of the laboratory methods.

In the case of regular gasoline, almost two octane numbers can be gained through increasing TEL from present average concentration to 3 ml. The 4th ml of TEL makes possible additional octane improvement.

Tetramethyllead

Research on tetramethyllead—first of a new group of lead alkyls to be offered commercially—shows that in highly aromatic gasolines or in engines prone to induce fuel segregation in the manifold, TML can be considerably more effective than TEL in its road performance.

Mixed Lead Alkyls

Now three more "Ethyl" antiknock compounds are available: MLA 250, MLA 500 and MLA 750—all produced from mixtures of TML and TEL processed to equilibrium composition. Current tests show that these mixed lead alkyls are selective in their ability to provide superior road performance, dependent upon such factors as fuel composition.

Custom Blends

You may find that a physical mixture of TEL and TML in some special ratio is most effective for your needs. Such "custom blends" are available.

Motor 33 Mix

Another compound, Motor 33 Mix—a manganese-lead antiknock—can supply several additional octane numbers when used in certain fuels.

The Future

With this variety of antiknock compounds, each with its particular value and application, maximum flexibility is offered to the refiner. Not only do the antiknocks offer cost savings and delay capital expenditures, but they can provide benefits that cannot be obtained any other way.

REMINDERS TO REFINERS

Antiknocks are your best octane improvement buy, whether costs are figured on Research, Motor or Road ratings.

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Gasoline sensitivity can be decreased with antiknocks.

Refining flexibility can be increased with antiknocks.

Antiknocks also can reduce or delay capital investment in octane improvement equipment.

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POLYELECTROLYTES . . . NEW

New coagulants and coagulant aids have brought about improvements that verge on the spectacular and should be investigated wherever coagulation is practiced.

INDUSTRIES' REQUIREMENTS OF WATER have been estimated to be more than 150 billion gallons per day. Much of this water must be clarified to remove turbidity, color and other impurities before it is suitable for use. The continued growth and expansion of industry has often taxed existing clarification equipment. In addition, contamination of rivers, streams and other surface waters often complicate the coagulation problem.

New materials have been introduced in recent years that bring about remarkable improvement in many difficult coagulation problems. These materials are organic polymers that contain recurring units of small molecular weight, chemically combined to produce high molecular weight polymers. Each of these recurring units carries one or more electrical charges or ionizable groups. Because they are polymers and have the characteristics of electrolytes, they have been designated as polymeric electrolytes or more commonly, polyelectrolytes. Polymers that dissociate to form positively charged polymeric ions are classed as cationic polyelectrolytes. Polymers that produce negatively charged polymeric ions are classed as anionic polyelectrolytes.

Coagulation and Floc Formation

Turbidity and color in natural water supplies are the main impurities normally encountered. Turbidity may be imparted by the presence of suspended matter or it may be due to a colloidal dispersion. Usually it is present in both forms. Color is mainly present in the colloidal state. Coarse suspensions will settle readily but the colloidally dispersed materials will remain suspended almost indefinitely. Table I illustrates the settling time required for particles of various sizes.

The theory underlying coagulation falls into the category of Colloidal or Surface Chemistry—a very complex subject. However, a brief description of the nature of a colloid's electrical charge will serve to explain the mechanism of coagulation and will also illustrate the role played by polyelectrolytes and coagulants in general.

The stability of a turbid water is attributed to the fact that colloidal particles carry the same charge. Identically charged particles repel each other, therefore, continued dispersion rather than precipitation is favored. The precipitation of colloidal particles, however, can be brought about by introducing ions of opposite charge. The relative precipitating power of ions increases markedly with increase in the ion's charge or valence. For example, the aluminum ion (Al^{+++}) is roughly 500 times as effective as the sodium ion (Na^{+}) for precipitating a negatively charged particle. Aluminum and ferric ions with three positive charges are the most commonly used coagulating ions. The polyelectrolytes with their recurring groups dissociate to form many electrically charged polymeric ions and their precipitating power is considerably greater than the precipitating power of the trivalent inorganic ions.

In addition to the mechanism of introducing ions of opposite charge to effect precipitation, the coagulant itself forms an insoluble, gelatinous precipitate or floc—such as aluminum hydroxide or ferric hydroxide—and this floc tends to agglomerate and absorb the turbidity and color particles. The settling rate is dependent upon the floc size, viscosity of the liquid medium (which is a function of temperature) and specific gravity of the floc micelle. Studies have shown that the specific gravity of the floc micelle is very greatly affected by the entrained water between the individual particles in the floc. The organic polyelectrolytes bridge together and greatly compress the individual particles so that less water exists in the micelle itself, thus creating a floc particle of greater density with a more rapid settling rate.

The number of contacts between individual particles per unit of time controls the rate of flocculation. Firmly bound particles better resist the shearing action of the fluid and permit more rapid agitation and faster floc formation. The polyelectrolytes produce tougher, larger and more uniform floc formation which in many cases can permit greater throughput from existing equipment.

Coagulation With Polyelectrolytes

Colloidal clay, the presence of which is one of the major contributing factors to

TABLE I VELOCITIES AT WHICH PARTICLES OF SAND AND SILT WILL SUBSIDE IN STILL WATER 10° C. OR 50° F.

SPECIFIC GRAVITY = 2.65

Diameter of Particle, in mm.	Order of Magnitude	Time Required to Settle 1 Foot
10.0	Gravel	0.3 seconds
1.0	Coarse Sand	3 seconds
0.1	Fine Sand	38 seconds
0.01	Silt	33 minutes
0.001	Bacteria	35 hours
0.0001	Clay Particles	230 days
0.00001	Colloidal Particles	63 years

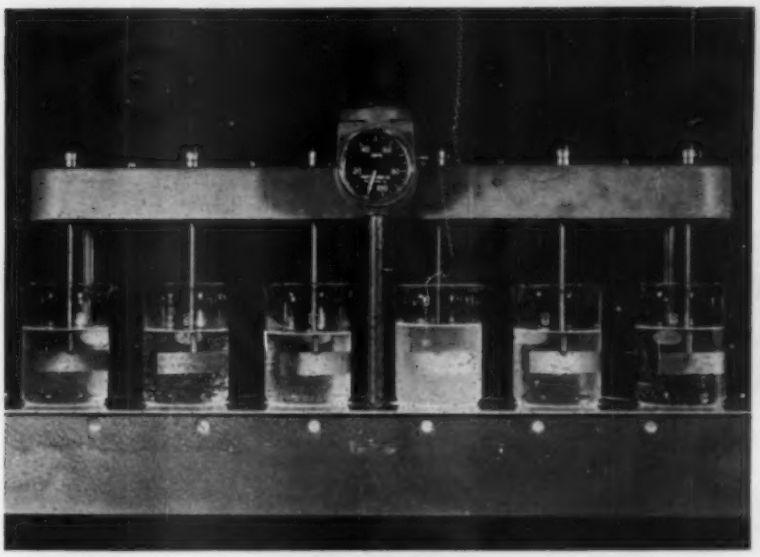

Figure 1—Jar tests in progress.

TOOLS FOR COAGULATION

turbidity of raw water, invariably carries a negative charge. Cationic polyelectrolytes are very effective flocculating agents for clay suspensions. Anionic polyelectrolytes do not flocculate clay suspensions, since both the clay and the anionic polymer have the same negative charge. However, if aluminum or ferric ions are added to initiate the floc formation then the addition of an anionic polymer will materially aid in the rapidity of floc formation as well as increase the settling rate and toughness of the floc. In this case, the anionic polyelectrolyte serves as a coagulant aid, whereas, the cationic polyelectrolytes can function as primary coagulants in the absence of the metal ion coagulants or as coagulant aids when used with the metal ion coagulants.

Jar Testing

When first considering the use of the polyelectrolytes as coagulants or coagulant aids, it is often best to employ a jar testing procedure. Jar testing apparatus is illustrated in Figure 1. The factors that are studied in a jar test are: pH, effect of various primary coagulants and coagulant aids, effect of weighting agents such as clay or calcite, and finally the effect of time and duration of agitation on the various combinations. The tests must be conducted systematically, changing one variable at a time, so that the best combination of primary coagulant, coagulant aid, weighting agent and pH may be determined. The criterion used in selecting the best combination is primarily based on the reduction or lack of turbidity and color in the supernatant water, together with the speed with which the floc forms, the characteristics of the floc and the speed of settling. Depending on the ultimate use of the water, chemical tests for residual aluminum and iron should also be used as a criterion. While the jar tests do not duplicate the conditions of the plant clarifier, they do serve as a good starting point for selecting the best combinations and treatment dosages required.

Case Histories

The use of polyelectrolytes quite often permits substantial increases in capacities of water clarifying units. In many cases this has been accomplished at no increase in cost. In other cases, the cost of the polyelectrolytes has not been justified on a continuous basis, but only during periods when difficulties are encountered with normal coagulation procedures.

In one particular refinery in the midwest, a sludge contact, vertical clarifier was employed to treat river water for various plant requirements. The clarifier had been operating at a flow rate of 1,200 to 1,300 gpm, using lime and ferrous sulfate for coagulation.

Due to very heavy demands on the unit, it was decided to try a water soluble polymer in the coagulation process. An aid of the anionic type exhibited desirable results in extensive jar tests and was, therefore, tried on the commercial unit.

With the use of the polyelectrolyte aid, it was found that the flow rate through the unit could be increased to 2,000 gpm. The quality of the effluent water was superior at the higher rate than the quality obtained without the aid at the original lower rate. One of the side effects of the treatment was that the sludge bed was decreased in volume, due to the higher density of the floc. Blowdown was, therefore, set at a lower rate.

At a northern paper mill, operation of the clarifier at 170 gpm consistently produced an effluent of relatively high turbidity due to carryover of floc. With the use of a polyelectrolyte coagulant aid, an effluent of excellent clarity was produced consistently at a flow of 250 gpm. The turbidity of the effluent was reduced from 16 to less than 5 units with the polyelectrolyte. The sludge density was increased and blowdown was decreased. Over-all treatment costs were reduced from an original 7.7¢ per 1,000 gallons to 4.0¢ per 1,000 gallons, including the cost of the polyelectrolyte aid.

If you have a coagulation problem, BETZ Laboratories will be pleased to offer recommendations. Why not call in a BETZ Field Engineer today? He'll be happy to discuss the problem with you. No obligation, of course.

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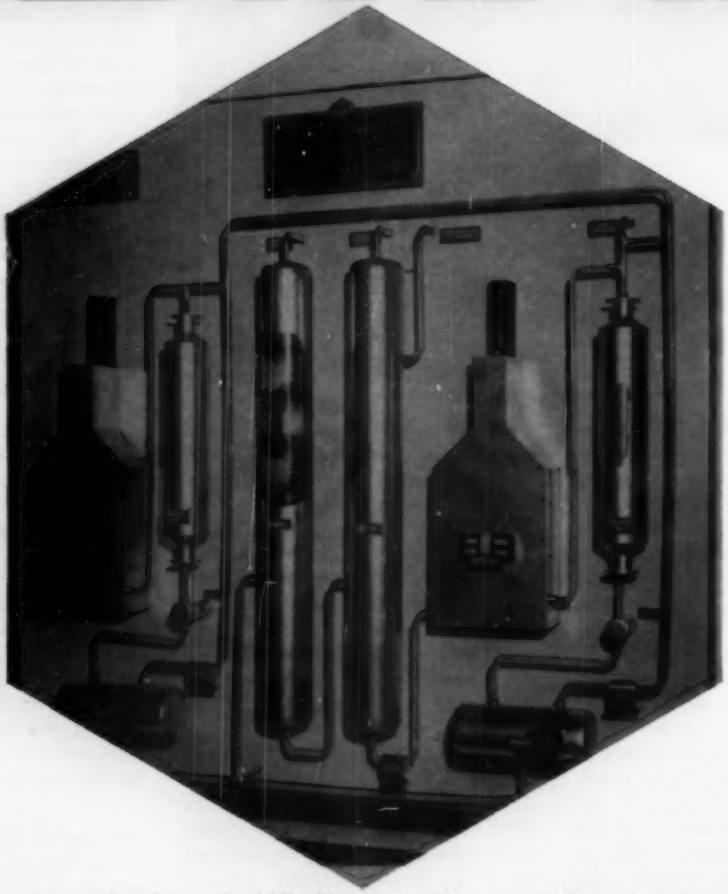

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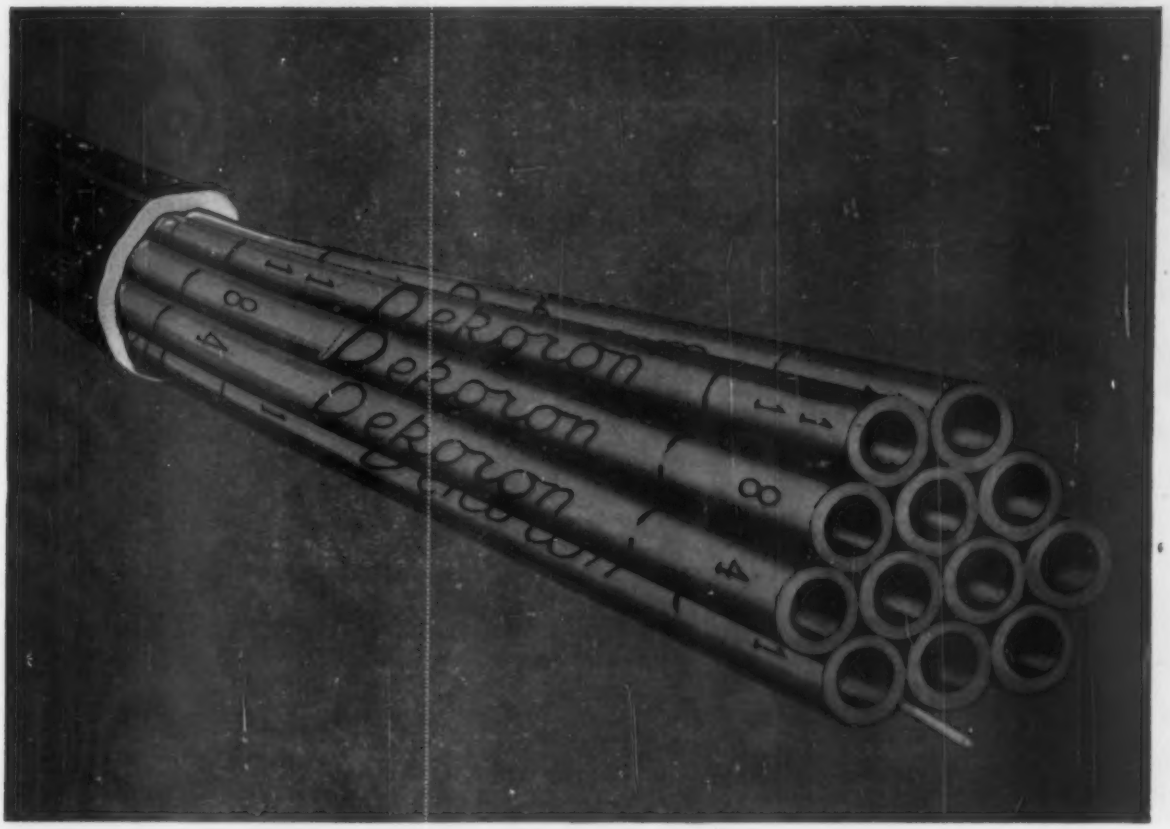

New Dekoron instrument harness design uses core of Anaconda precision copper tubes

The new parallel-construction Dekoron* "Metl-Cor" instrument harness offers many interesting features. All the tubes are number-coded for faster installation. Because the tubes are parallel, there are no low spots or moisture traps – and as tubes need not be straightened, take-offs are easier to make. The tubes are protected from corrosion and physical damage by a sheath of improved polyethylene. New Dekoron "Metl-Cor," a product of Samuel Moore & Company, Mantua, Ohio, is available in lengths up to 1000 feet.

In this new product, as in other Dekoron instrument tube bundles, Samuel Moore & Co. uses Anaconda Copper Tubing because it consistently meets its rigid quality requirements and is available in unusually long lengths. Special care is taken by Anaconda to maintain dimensional accuracy and uniform soft temper throughout the length. It also makes sure that surfaces are clean, smooth, and bright, free from dirt, dust, or metal chips.

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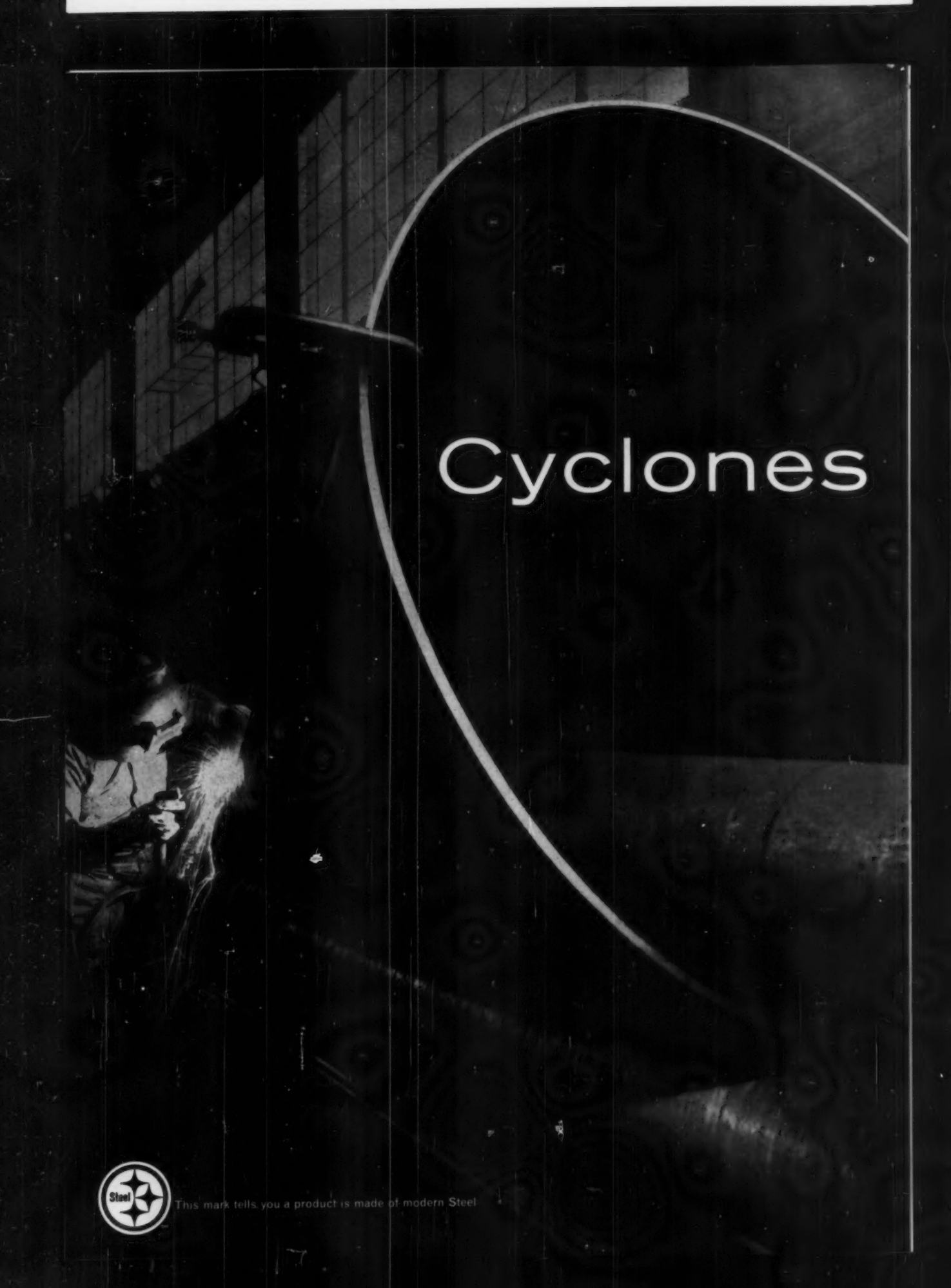
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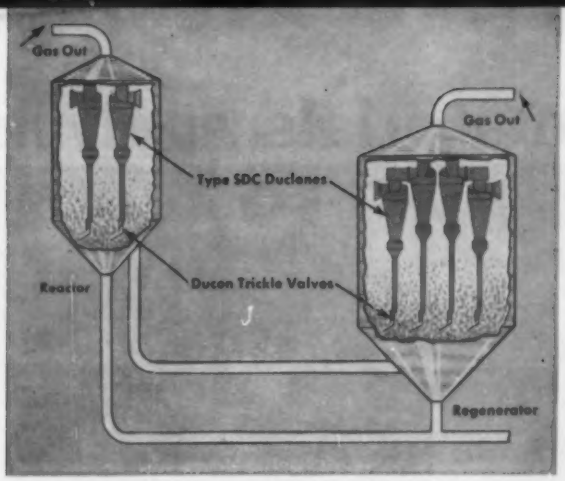

General arrangement of Ducon cyclones in the reactor and regenerator of a fluid catalytic cracking unit. Stainless cyclone collectors keep catalyst loss to a minimum. "Duclone" is a registered trademark of the Ducon Co.

start here...

. . . and end up in fluid bed cat crackers where they circulate up to 60 tons of catalyst every minute. At $400 to $500 a ton, lost catalyst can put a lot of red ink into a refinery's operating budget. Breakdowns cost from $20,000 to $50,000 a day. That's why it is so important to design with the right material from the start: USS Stainless Steel.

Stainless Steel cyclones used for catalyst recovery are subjected to extreme heat and erosion. Temperatures in a regenerator unit can go as high as 1400° F. At high temperatures elemental sulfur corrosion would eat out most materials in nothing flat. Not Stainless. And Stainless Steel retains its strength at high temperatures. Stainless cyclones aren't in danger of changing shape which could cause catalyst loss.

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If you are interested in more information about these Stainless Steel cyclones, wire or write U.S. Steel, Room 6104, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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Left, welder completes longitudinal seam of one segment of the cyclone at The Ducon Company's Mineola, N.Y. plant. **Below,** stainless steel cone is removed from the forming rolls.

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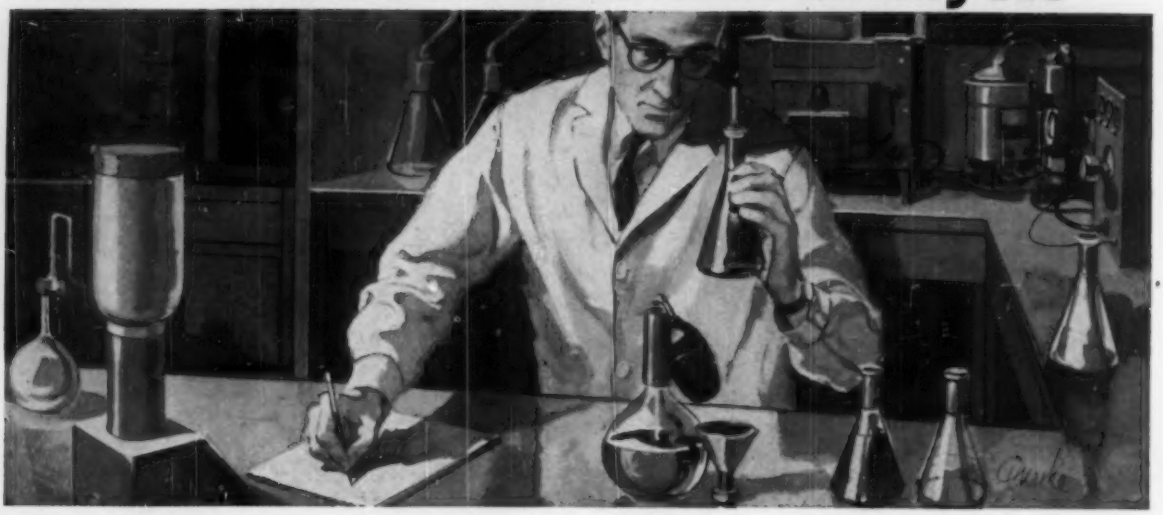

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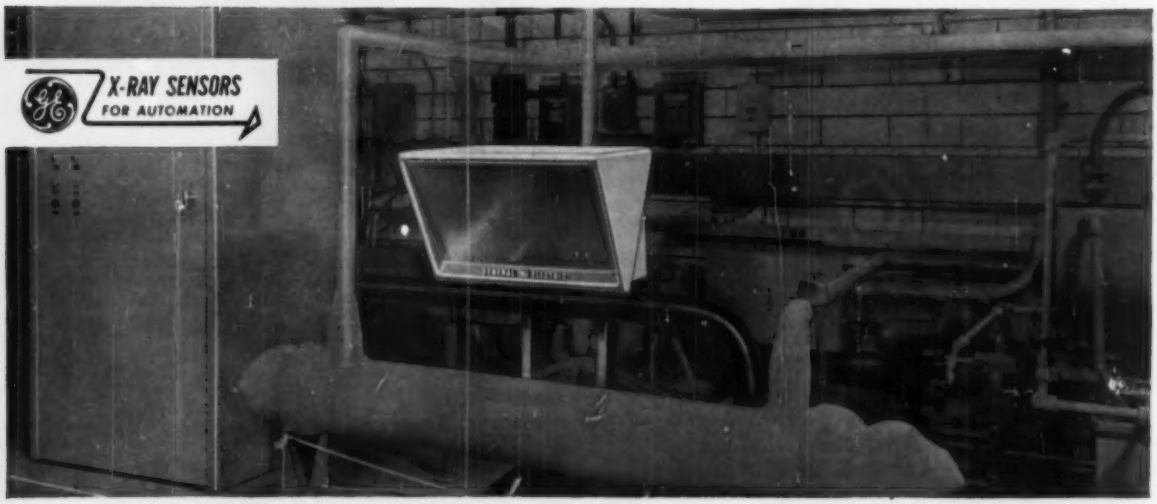

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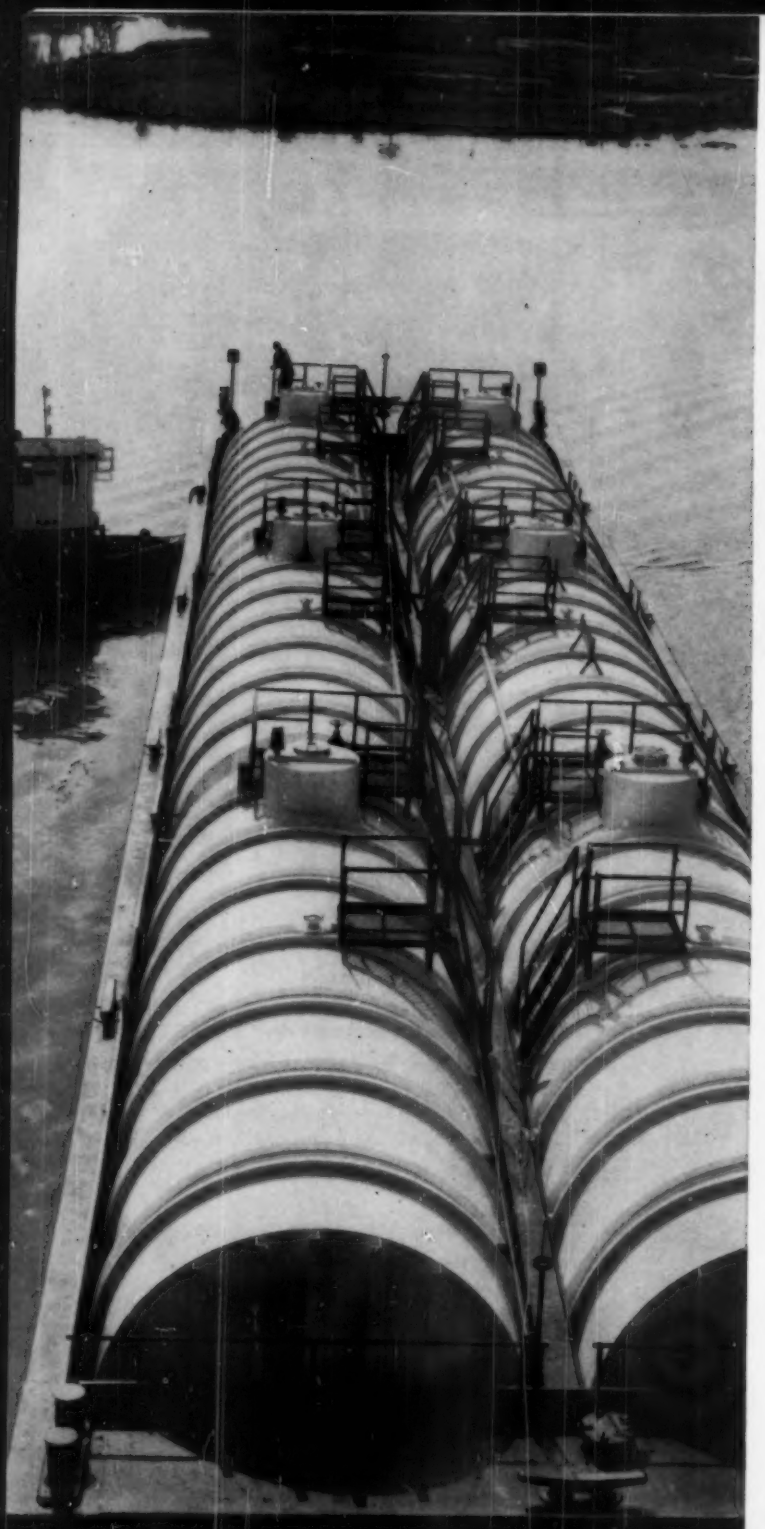

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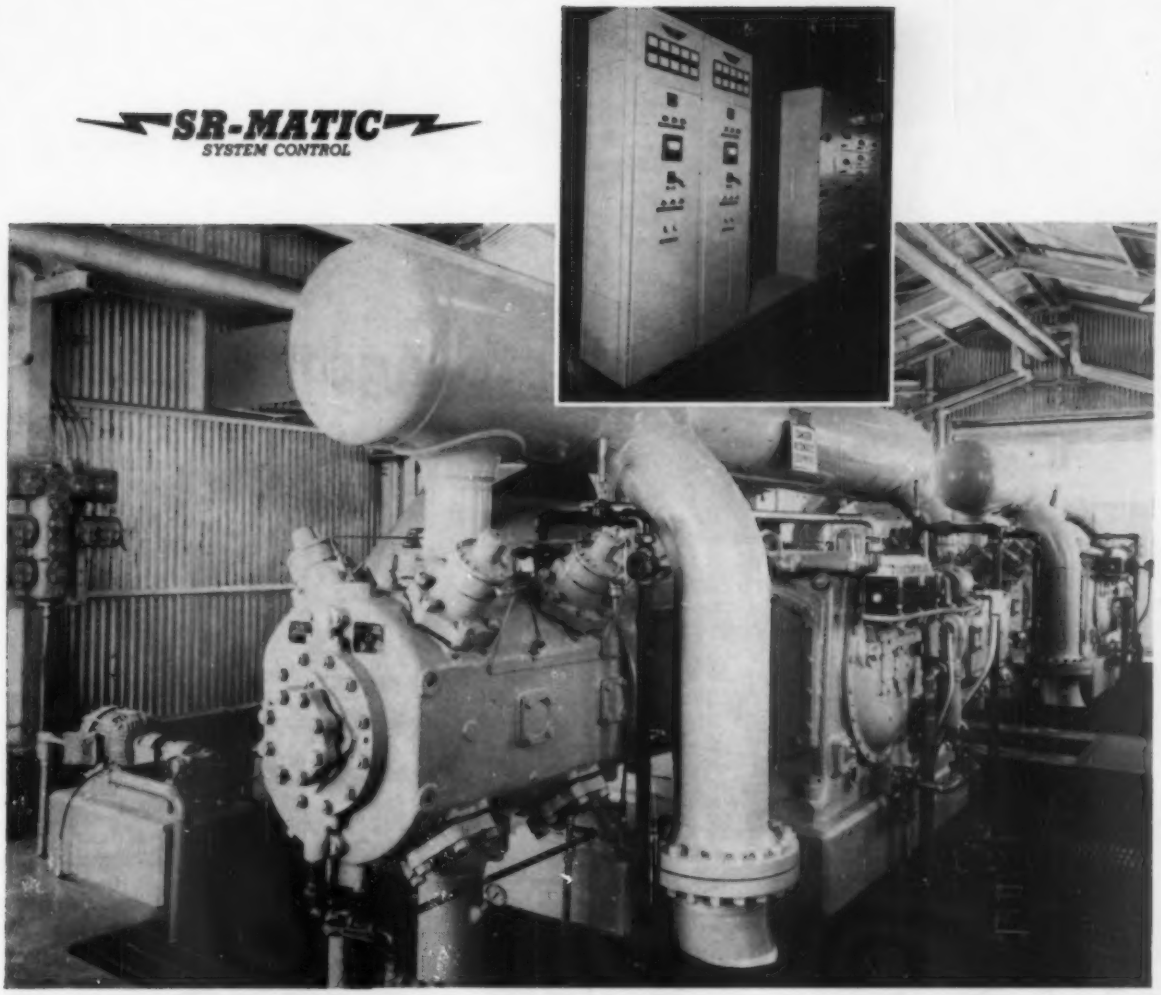

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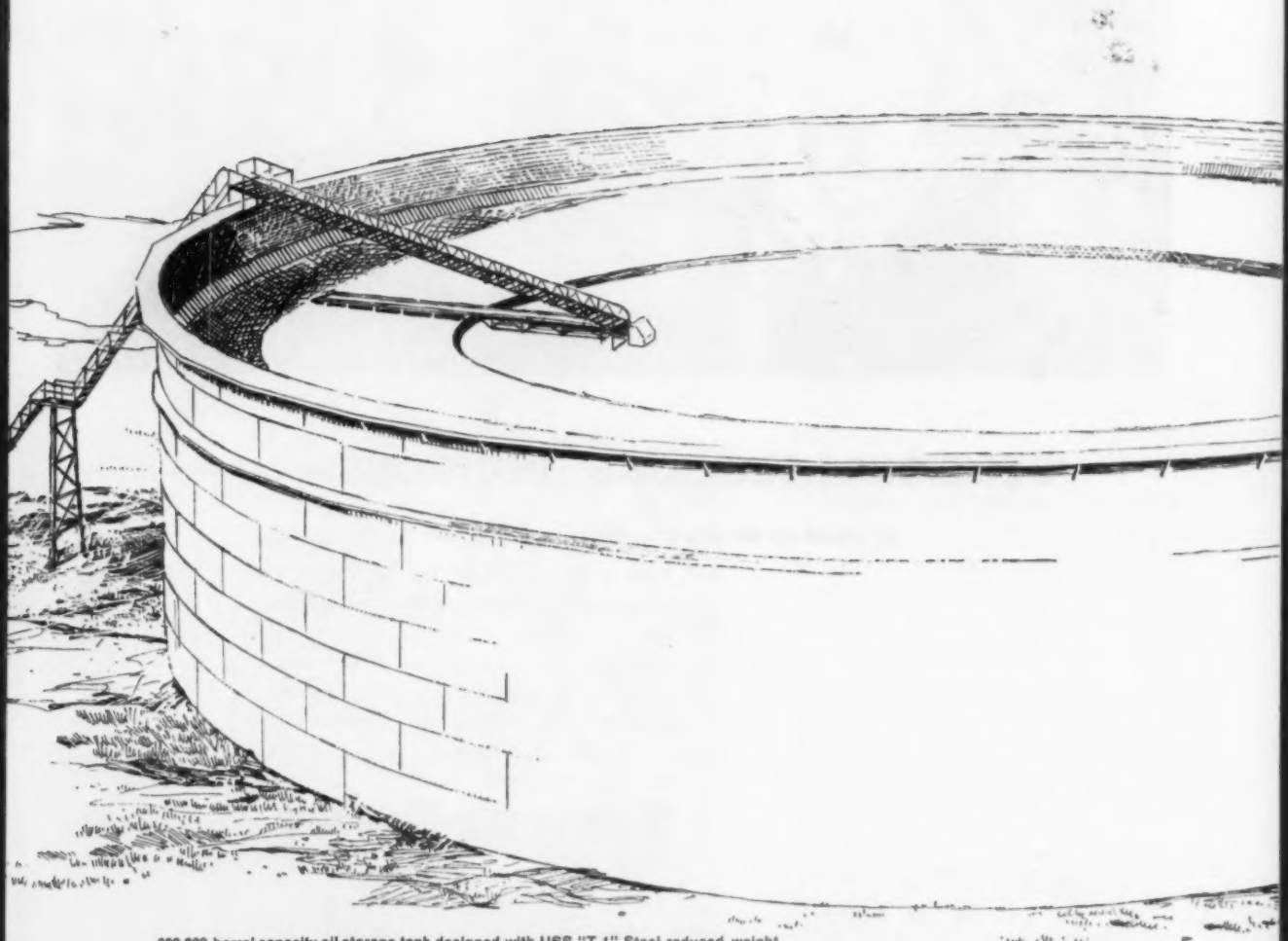

600,000-barrel capacity oil storage tank designed with USS "T-1" Steel reduced weight by about 42%, with substantial savings in fabrication, freight and erection costs.

This mark tells you a product is made of modern, dependable Steel.

USS "T-1" Steel

A new 600,000-barrel oil tank 260 feet in diameter and 64 feet high has been erected for the American Independent Oil Company in Mena Abdulla, Kuwait, on the Arabian Gulf.

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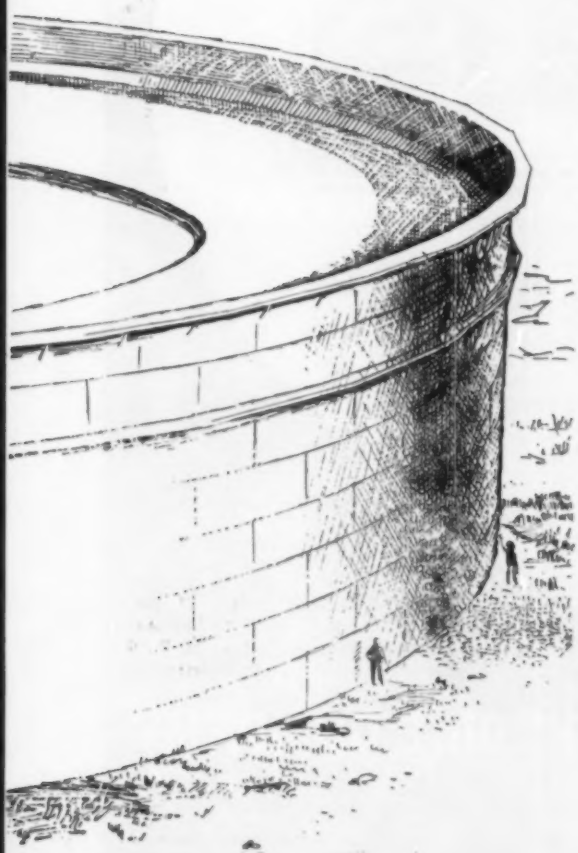
The Chicago Bridge & Iron Company obtained the contract for the tank with a design that took advantage of the *extra* high strength of USS "T-1" Constructional Alloy Steel and its many cost-saving features.

The shell consists of six 8-foot rings of "T-1" Steel, made to 115,000 psi minimum ultimate strength, and two top 8-foot rings made of A 131 grade A carbon steel. The tank has a Horton pontoon floating roof and the bottom of the vessel was made of A 283 grade C plates ¼-inch thick.



USS "T-1" Steel reduces weight. The "T-1" shell thicknesses, which ranged from 1 inch down to ½ inch, were determined on the basis of a design stress of 38,333 psi. This is ⅓ of the minimum ultimate strength of the steel. Joint efficiency was calculated at 100%, with a product specific gravity of 0.90. The top two carbon steel rings were figured for the API 12-C allowable stress of 21,000 psi, with 100% joint efficiency, and with a product specific gravity of 1.0. Steel thicknesses were ½ inch and ⅜ inch.

Although API prohibits the use of carbon steel plates in the thicknesses that would have been needed for the 6 lower rings, by using USS "T-1", 42% less steel was required. Fabricating, shipping, and erecting costs were thus considerably lower than original estimates.

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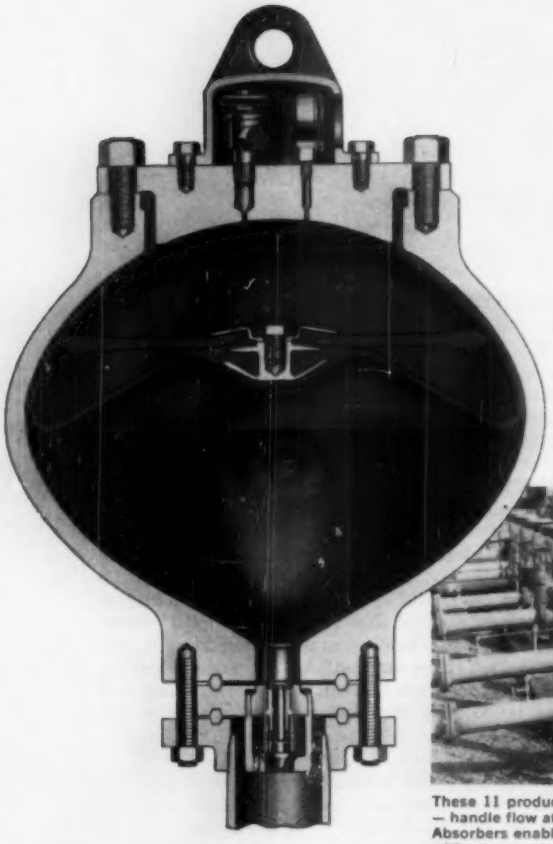

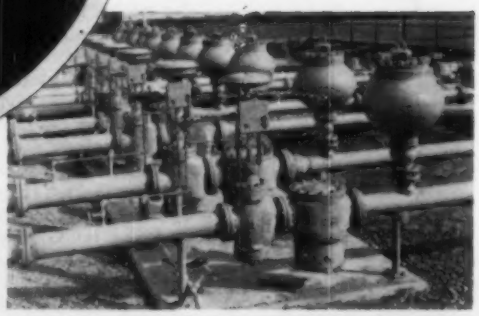

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DL-230

Advances in cracking catalysts

BEN H. LOPER

ROBERT M. DeBAUN

BEN H. LOPER is manager of research and development for the refinery chemicals department of American Cyanamid Company, headquartered in Stamford, Connecticut. Joining the company in 1950, he has served successively as supervisor of various catalyst operations at plants in Fort Worth, Texas, and Michigan City, Indiana; as plant engineer at Michigan City, and as a technical representative and later technical director of the refinery chemicals department. He holds a BS in chemical engineering from Illinois Institute of Technology.

ROBERT M. DeBAUN, group leader of refinery catalysts research in the industrial chemicals division of American Cyanamid Company, was a project supervisor with General Foods Corporation before coming to Cyanamid in 1955. His experience with Cyanamid includes service as supervisor of the mathematical analysis group, responsible for the design and analysis of experiments. DeBaun, who has BS and PhD degrees in chemistry from Fordham University, is author of 17 published scientific papers and 13 presentations to scientific groups.

FLUID CRACKING CATALYST development has proceeded, in general, along two main pathways . . . naturally occurring materials and synthetics.

The first catalysts used in the cracking process were simply halloysite or montmorillonite clays that were dug out of the ground, acid treated, brought to the proper size ranged, and calcined. Succeeding products in this series were more and more refined, the result of more elaborate chemical treatments of the original clay. Thus these materials have become more "synthetic," and their catalytic and other properties, in fact, have tended to approach those of synthetic catalysts.

Wholly synthetic materials also appeared early in the use of the process, and these materials have evolved in the direction of constantly improving physical and chemical properties. A new type of synthetic catalyst has also appeared in which naturally occurring clay minerals are used, together with synthetic components. Also, the synthetic catalyst field has seen the use of varying compositions, although in general silica-alumina composites have been the most popular. Thus, in this field, evolution has tended, on the one hand, toward production of synthetic materials containing natural products and thus to lower cost products, and on the other hand, to improved wholly synthetic catalysts of varying compositions. These ideas are shown graphically in Fig. 1.

The various catalysts available throughout this historical process and available today can be compared in a variety of ways. Generally speaking, they may be compared catalytically and physically as indicated in Table I.

Catalytic properties

1. Activity. With respect to catalytic activity, catalysts of both main groups have gradually increased in catalytic activity over the years. Activity is defined as the conversion of materials boiling within the gas oil range to materials boiling below the gas oil range and the conversion of materials boiling within the heavy end of the gas oil range to materials boiling within the light end of the gas oil range.[1] Since the purpose of the catalytic cracker is to convert heavy boiling materials to such lighter boiling materials, high activity is a requisite for all catalysts to

Table 1. Important Catalyst Properties.

Physical	Catalytic
Particle Shape	Activity
Particle Size Distribution	Activity-Stability
Particle Density	Selectivity
Apparent Bulk Density	Selectivity-Stability
Fluid Bed Properties	Sensitivity to Sulfur in Feed
Heat Capacity	Sensitivity to Metals in Feed
	Regenerability

be used in this process. Other things being equal, material of initial high activity is to be preferred over material of low initial activity. On the other hand, the stability of the catalytic activity is of equal importance with the initial activity of the catalyst. In general, it may be said that catalysts prepared from naturally-occurring materials tend to have lower initial activities, although in many cases, their activity-stability has been good enough to permit their profitable use in fluid cracking operations. Activity-stability is important primarily in order to maintain the whole catalyst inventory. If catalyst loses activity rapidly under use, then the processor will find it necessary to discard catalyst from inventory in order to be able to add sufficient fresh catalyst to maintain activity of the whole inventory at a sufficiently high level.

Activity-stability of commercial fluid catalyst has certainly improved over the years.[2] As a matter of fact, catalyst usage rates of 1 to 2 lb per bbl were once common, while at the present time usage rates of more than 0.5 lb per bbl are considered quite high. This trend is due to improved operation of catalytic units, improved catalyst recovery systems, and to improved catalyst properties such as catalyst attrition resistance and activity-stability. For example, in many cases the use of 25% alumina synthetic catalyst over 13% alumina catalyst can be justified on the basis of improved activity-stability.

2. Selectivity. Catalyst selectivity, however, is equally as important as catalyst activity.[2] As a matter of fact, the definition of catalyst activity contains certain assumptions as to the nature of the selectivity related to the catalyst activity being measured. Thus, it might be (theoretically) possible for a catalyst to convert a gas oil only to material boiling still within the gas oil range, but at the lower end of that range. Such a catalyst might have very high activity for this process and yet its activity would not be detected under the normal conditions of measuring catalyst activity.

From the standpoint of catalyst selectivity, use of natural catalysts results in equal or slightly higher yields of gasoline product and middle distillates, together with the production of a more olefinic gasoline of lower octane number than are produced over silica-alumina catalyst. Accordingly, when attempting to decide between natural catalyst and silica-alumina catalyst on the basis of selectivity, the engineer will have to weigh the relative value of yields and qualities of the gasoline yields available, the availability of other sources of high octane components and his marketing mixture generally.

Within the general group of synthetic catalysts, a wide variety of compositions can be considered. If we take silica-alumina catalyst as standard, the difference between so-called low alumina (13% Al_2O_3) catalyst and high alumina (25% Al_2O_3) catalyst is in the amount of catalytic activity which they show and the stability of that activity under commercial usage. The selectivity of both these catalysts can be considered the same both in the laboratory and in commercial use. Therefore, as mentioned above, a decision between these two catalyst types will be based on balancing fresh catalyst cost with the greater activity-stability of the high alumina type.

On the other hand, within the synthetic group, marked changes in selectivity can be achieved by utilizing other catalyst compositions. For example, it is well known that the use of silica-magnesia catalyst as opposed to silica-alumina catalyst produces marked increases in the yield of gasoline and light cycle oil. However, the gasoline produced is more olefinic and less aromatic than that produced over silica-alumina catalyst and has a lower research octane number. On the other hand, the response to lead of the gasoline is relatively good and the distillation properties of the gasoline are such that it appears to have a rather heavy front end. This permits the incorporation of larger amounts of butane in the gasoline. Early attempts to use silica-magnesia catalyst were dogged by regeneration problems, which are discussed in more detail below.

Use of silica-alumina-magnesia catalyst is being investigated intensively in several refineries.[3] These catalysts appear to offer moderate increases in gasoline yield over silica-alumina catalyst so gasoline yield will be equal or superior to that obtained over naturally-occurring catalysts, although much lower than that obtained over straight silica-magnesia catalyst. On the other hand, the research and motor octanes of the resulting gasoline are fully equivalent to those of the gasolines obtained over silica-alumina catalyst and superior to those of the gasoline obtained over natural catalyst and silica-magnesia catalyst. Chemically speaking, the gasoline appears slightly olefinic relative to that obtained over silica-alumina catalyst, although not so olefinic as that obtained over natural catalyst. Moreover, the yield of the more useful light gases, namely propylene and butylene, can be increased with the use of such a composition over the yield obtained with silica-alumina catalyst. Of equal importance, the use of these 3-component catalysts appear to result in lower coke production. This can mean added throughput for units with a coke burning limitation.

These remarks on selectivity are based largely on laboratory and pilot

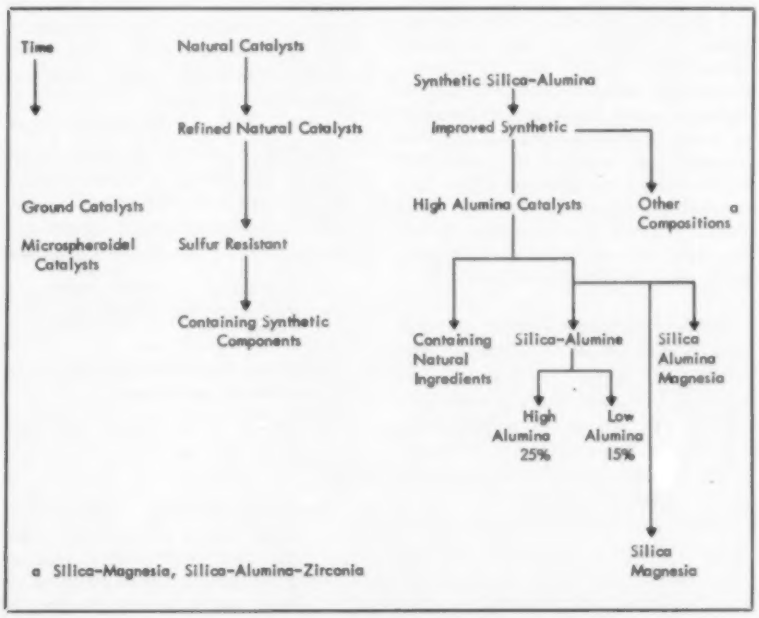


FIG. 1. Development of fluid cracking catalysts.

plant data and await the outcome of several current catalyst trials for their full-scale proof. Several catalysts of this type are being tried in refineries at this time. It is too early to judge product distributions accurately, as the expected differences from former operation are quite subtle, but it can be said this catalyst type appears fully operable, relative to existing commercial fluid cracking catalyst.

Stability of selectivity is, of course, equally as essential as stability of activity. When processing clean feeds, all catalysts used commercially show stability of selectivity which is entirely satisfactory. Earlier catalysts derived from natural materials tended to show undesirable stability of activity and selectivity when processing high sulfur feeds. It is believed that this is due to the presence of iron in the catalyst and that in processing of high sulfur feeds, the iron becomes activated, being converted from iron oxide to iron sulfide, and that the resulting iron sulfide behaves in the cat cracker as a dehydrogenation catalyst. This is believed to poison the cracking activity of the catalyst, changing the selectivity to produce undesirably large quantities of carbon and gas during the cracking process. This difficulty was avoided by the use of so-called sulfur resistant natural catalysts, which were more nearly like silica-alumina catalyst in their behavior in processing feeds high in sulfur.

On the other hand, all catalyst so far known are materially injured in selectivity properties when processing feeds high in certain heavy metals, specifically nickel, copper, and vanadium, and to a much lesser extent, iron. In such cases these metals undergo transformation to catalytically active oxides on the surface of the catalyst and behave as dehydrogenation catalysts, producing large yield of carbon and less useful gases such as C_1 and C_2 hydrocarbons and H_2, to the detriment of the yield of gasoline and cycle oil. This is true in general for all cracking catalysts presently in commercial use.

It is possible to minimize the effect of such metals by using large quantities of fresh catalyst, purging the inventory frequently to maintain the same total amount of catalyst in the cracking unit.[1] Such a process, of course, requires the use of lower cost catalyst. The use of natural catalyst can certainly be imagined in this connection. However, manufacturers of synthetic catalyst have developed catalyst which, while basically synthetic, can be used at higher rates due to their lower cost. In this way, the harmful metals can be purged from the unit without undertaking a natural catalyst type of selectivity. In such a case, the use of low cost catalyst can be obtained without the loss of gasoline octane that can result from using natural catalyst.

No matter how stable a catalyst is, continuous reaction and regeneration cycles change various catalytic properties substantially. Various catalysts are affected to different degrees, but in all cases the direction of change is the same.

3. Changes in catalyst properties on use. Deactivation takes place via (a) loss of surface area, and (b) loss of activity per unit surface area. Only sodium among metals has been found to influence the loss of surface area, and seriously does so only above about 0.5%. Iron and nickel do not show this effect. In the case of sodium, surface area was found to be 10% lower after 20 hours steaming at 1250 F due to 0.7% Na. Thermal treatment at 900 C for 5 hours gives 22 vol. act. with 0.7% Na_2o as compared to 60 without. Inasmuch as sodium has been found to have a measurable effect on activity and thermal stability at 0.1% Na it is concluded that most of this effect is due to loss of activity per unit of surface area.

Since iron and nickel do not cause loss in area, they must act by causing loss of activity per unit area. The same is true for other heavy metals. This is thought to be done by physical adsorption and blocking of the acid sites, but site blocking may also be attributed to coke formation with the coke doing the blocking. The phases of heavy metal deactivation probably include (a) an active period in which they are strong coke-formers (and indirectly activity depressants) and (b) an inactive period which follows. The inactivity may result from sintering caused by tremendous heat release in the zone immediately around the adsorbed metal during regeneration. This later inactive period would therefore show the same effect as sodium does at first, i.e., loss of surface area as trapping occurs.

Heat without steam causes a loss in area with a proportional loss in pore volume so that pore diameter remains constant.[4] One can visualize a mechanism for this only to the extent of saying that a large number of micelles come to behave like one impenetrable zone within a particle. No micelle growth occurs. Heat with steam promotes or allows micelle growth, also an increase in pore diameter. As micelles grow, further growth becomes increasingly difficult. As catalyst deactivates it becomes more susceptible to poisons, probably due to loss in surface area. Old catalyst is mechanically stronger, and denser, and less active than new catalyst, at least for synthetic catalyst. It contains more metals but part of these metals are in the inactive phase. In line with this, fresh metal deposits probably are increasingly effective as the surface area declines; therefore, it would appear that the deactivation process accelerates if heavy metals are present in the feed.

Units equipped with highly efficient recovery systems will probably operate on a withdrawal program. Whether selective (via classification) or bulk, withdrawal will provide control of the metals content of the average circulating catalyst. However, it is probable that the metals eliminated by withdrawal are less potent, as noted above, than the metals in the stack-loss. This would be logical because withdrawn catalyst should presumably include the high-density particles which were initially very rugged and able to resist attrition, and which later gained density so as to prevent escape through the cyclones. These high-density particles would continue to accumulate metals, which would gradually evolve to the inactive phase.

On the other hand, fines capable of escape from the cyclones are probably representative of fragments from less rugged, and therefore younger, particles. Since they are relatively young, the contained metals are probably both young and active. Some refiners, particularly those with good recovery systems, report higher metals content in stack fines than in bulk circulating inventory. This suggests a dual effect — quantity plus poison activity — favoring good selectivity control by stack purge.

In this situation, an efficient recovery system is assumed. Another change catalysts go through is a continued increase in attrition resistance. Two particles of fresh catalyst can be pictured as experiencing the following history.

a. Particle A is softer (more fragile) and less round than B as made.

b. When first used, both start with identical activities.

c. Within a few cycles, both particles pick up metals at or near the surface.

d. Soon afterward, some pieces break off A and escape. These are still quite high in surface area, but the metals on them are fresh and active as poisons and activity depressants.

e. The remaining main body of A, because of the loss of surface fragments, has a lower metal content, and is therefore more desirable as a cracking agent than formerly and also more desirable than B.

f. Particle A continues to disintegrate in this manner. The remaining principal portion always constitutes one of the best elements in the circulating inventory.

g. Particle B resists mechanical breakdown, gradually losing surface area and porosity, gradually gaining in density as deactivation proceeds. In the interior of B, where heavy metals do not penetrate, deactivation probably occurs by localized high heat release from normal cracked coke, plus sodium attack. In the surface region, where metals accumulate, the heat release effect is accentuated and accelerates.

h. Particle B eventually escapes by withdrawal, otherwise rides through the system repeatedly as a very low activity, very poor selectivity cracking agent, carrying a high concentration of heavy metals.

Based on the preceding, excessively high attrition resistance is bad. To the extent that it continues in some particles, a selective withdrawal program will be of value in purging the B-type particles from an equilibrium system. It is an objective of catalyst manufacturers to achieve greater uniformity of product, so that A and B are not far from the average resistance to attrition. Moreover, required attrition resistance should be achieved as much as possible through particle shape rather than particle hardness. The newer synthetic and semi-synthetic catalysts have achieved this, whereas there is considerable variability in particle shape in the strict natural clay catalysts.

Minimum reactor inventory has been observed to favor better activity maintenance and better selectivity (lower coke yield). This is logical because catalyst mixing in the reactor provides for a more or less uniform coke concentration throughput the bed, and coke is a carbon-forming catalyst in itself although less active than silica-alumina. The lower the reactor inventory, the more cracking is done by freshly regenerated catalyst in the reactor riser and the less by "average" reactor catalyst in the reactor itself. For each refinery operation there is an optimum rate of catalyst usage, determined by the desired selectivity and activity. Obviously, catalyst losses may force a refiner to a make up rate higher than economical and too, catalyst losses have a marked effect on the particle size distribution of the equilibrium catalyst.

Consideration of the effects of catalyst usage, catalyst loss, and unit inventories, shows the whole picture as an interlocking one where a change in one of the variables affects all or at least part of the others, sometimes to a great extent. An explanation of this pattern is as follows:

a. For a given catalyst addition rate, equilibrium catalyst activity will increase as unit catalyst inventory decreases.

b. Equilibrium catalyst activity increases with increased addition rate when losses are low or moderate (on the order of 0.1 to 0.3 pounds per bbl fresh feed).

c. Catalyst losses increase with increased catalyst inventories due both to reduced regenerator freeboard and increased production of fines by attrition.

d. The increased need for fresh catalyst additions when inventories are raised further increases losses because fresh catalyst attrits more readily and is more difficult to recover in cyclones than comparable size equilibrium particles.

e. As catalyst inventories decrease, for a given fresh catalyst make up rate, the equilibrium will more closely approach the particle size distribution of the fresh catalyst.

f. As equilibrium catalyst becomes coarser (average particle size increases) regeneration becomes more difficult, the carbon content of regenerated catalyst increases, product distribution becomes less profitable and coke laydown at a given conversion increases.

g. As coke laydown increases, regeneration gas velocities increase (to the limit of the blower capacity) and catalyst losses increase.

h. A poorly fluidized bed will cause increased catalyst losses due to erratic (bumping or slugging) behavior.

Obviously, the above considerations point to the desirability of operating with the lowest practical catalyst inventory and the employment of a catalyst recovery system adequate to hold catalyst losses to a low level.

Physical properties

The most obvious physical properties of the catalyst important in the operation of a cat cracker are the distribution of catalyst particle size and also the shape of the catalyst particle. In earlier times it was common to use ground catalyst; that is, catalyst which had been brought to size by the action of grinding. Although the equilibrium catalyst produced from such fresh catalyst might have the desirable spherical particle shapes, fresh catalyst had many jagged edges and fluidized poorly in addition to giving rise to great losses of catalyst in the early stages by attrition. Present day catalysts, however, are almost all microspheroidal and hence are of suitable particle shape even when fresh. It is important to have a catalyst with good flow properties for the entire cracking unit system and one that will provide the minimum amount of particles that will be lost from the cyclone system. The equilibrium particle size distribution is going to be determined by the efficiency of the catalyst collection system, the fresh catalyst particle size distribution and the catalyst attrition rate. Particle size distribution will affect the fluidization, circulation, and carbon burning of the catalyst.

Practically all catalysts produced today have close cut particle size distribution; that is, they contain a maximum amount of catalyst between 40 and 80 microns. This should be compared to the particle size distribution of catalysts produced a few years ago (Table 2). Catalysts vary widely in bulk density and attrition properties even today. The natural type products tend to have poor attrition resistance, and to be heavy density fresh catalysts. However, the natural products, even the semi-synthetics completely derived from clay, do not change bulk density substantially on use as do synthetic silica-alumina catalysts and 3-component catalysts. These facts must be considered when selecting a fresh catalyst.

Table 2. Fresh Catalyst Particle Size Distribution.

	Typical, 1950		Typical, 1960		
	Fine	Coarse	Fine	Intermediate	Coarse
+80 microns	7	31	5	15	27
40–80 microns	74	48	75	71	61
20–40 microns	16	15	18	12	10
—20 microns	3	6	2	2	2

Distribution of particle sizes is still extremely important as it will relate

to the rate of loss of catalyst from the unit. All things being equal, of course, fine catalyst particles tend to be lost from the units more readily than coarse catalyst particles. Hence it is desirable and possible to obtain relatively coarser catalyst for most units. Many cracking units are fitted with cyclones and other catalyst recovery equipment which makes this requirement less strict. Many studies have been made to examine the properties of catalyst particles in fluid beds and also the flow properties of the catalyst in transfer lines.[5] The principal features influencing such properties are of course, the particle size distribution and the bulk density of the catalyst. The bulk density of equilibrium catalyst is in general different from that observed in fresh catalyst. This is due partly to the removal of certain size fractions in use and also to the sintering or otherwise described physical changes of the catalyst particles in use. One of the phenomena which may occur in some catalysts, as noted before, is closure of catalyst pores over air or carbon containing spaces to produce skeletally lighter catalyst, while other catalysts may sinter in such a manner as to produce a hard, solid mass which will have much higher particle density. In either case, these properties, together with the particle size distribution, will influence the density of the expanded bed of fluidized catalyst and also will influence the density of the catalyst slurries in transfer lines, influencing profoundly the gas mixing patterns in the reactor and rates of transfer and delicacy of control of transfer which can be achieved in moving the catalyst about the unit.

Of course, attrition of the catalyst is an extremely important property and in general it is more desirable to have hard and less easily attrited catalyst than to have soft and fragile catalyst particles. Even relatively soft catalyst can be said to be an extremely hard substance as evidenced by the scouring and corrosion which is produced in the interior portions of catalytic cracking units. Moreover, attrition provides one device whereby the inventory is continually refreshed. An undesirable feature of the attrition of catalyst is that it proceeds most rapidly when the catalyst is fresh and therefore most desirable for catalytic cracking purposes. Unfortunately, this property cannot be avoided. However, all catalyst manufacturers attempt to produce catalyst which is as attrition resistant as possible. Indeed, within the realm of synthetic catalyst materials, the attrition resistance of these catalysts has increased markedly within the last five-ten years. As noted before, this has been one of the main features in permitting the drastic decrease in catalyst usage which most refiners have shown in the last several years.

Heat capacity is another important physical property of catalysts which should be mentioned. One of the main purposes served by the catalyst in a fluid catalytic cracking unit is that of transferring heat, generated by the burning off of the coke in the regeneration process, from the regenerator back to the reactor. Another aspect of the possible value of heat capacity is that if catalyst has relatively higher heat capacity, it should be more resistant to harmful changes produced by the heat generated by the regeneration of the coke from the surface of the catalyst. Usually this heat capacity can be associated with the skeletal density of the catalyst and particularly with the content of alumina relative to silica within the catalyst skeleton. This property has received greater recognition in the last few years while operators have taken steps to reduce the catalyst circulation rate. Also, it is quite probable that reduced circulation rates aid in catalyst stripping, thus substantially reducing air usage rate in the regenerator.

Regenerability

Of course when speaking of catalyst selectivity and selectivity-stability, one of the most important catalytic properties of cracking catalysts and one which may be looked at again from the point of view of activity and selectivity, but most profitably from the point of view of activity, is the fact the catalyst must be fully regenerable. With only one exception, all catalysts studied and tried in commercial use have had relatively little difficulty in regeneration. The one notable exception was silica-magnesia catalysts. It was observed in earlier trials that the carbon deposits produced during catalytic cracking became more and more difficult to regenerate as the use of catalyst continued and the catalyst became older in the unit. Indeed, the coke deposits became relatively graphitic and refractory to regeneration.[6] Certainly the property of regeneration and of easy regeneration in particular is essential to all cracking catalysts and one which is shared by the majority of cracking catalysts offered for sale today.

Some factors affecting the ease of burning coke from cracking catalysts that are in turn affected by the type of catalyst being used are:

1. regeneration temperatures,
2. character of coke lay-down,
3. residence times of catalyst in the regenerator and
4. air usage.

One of the advantages of the new and more stable synthetic and semi-synthetic catalysts is that units can be operated at higher regenerator temperatures, thus effecting more complete coke burn-off and providing circulating catalyst with higher total Btu's as a heat source. Due to this, it is now quite common to operate at 1130 to 1200 F regenerator temperatures. This is not practical with the pure clay catalyst.

There is evidence that more active catalysts such as the high alumina materials deposit coke that burns more readily. One major operator has found that the coke deposit on the fresh catalyst is a long chain polymer rather than a dense, low hydrogen content coke normally found on low activity equilibrium catalyst. The polymeric material burns more readily, and probably the higher temperature developed by such burning is a primary cause of rapid deactivation of fresh catalyst. The residence time of catalyst in the regenerator is expressed by the regenerator inventory divided by the catalyst circulation rate and can be controlled over a wide range by changing either or both of these variables. Thus a catalyst such as the newer synthetics, that can take higher heat and thus reduce circulation rate, is a catalyst to be desired. It is also desirable to maintain a low unit inventory to allow more free-board in the regenerator and thus reduce catalyst losses and to provide for a greater effect of a given fresh catalyst addition rate, as mentioned previously.

One effect of low addition rate of catalyst is the resultant high heavy metals concentration on the surface. These metals, even when not active enough to cause changes in selectivity in cracking, can act as oxidation catalysts in regenerating and cause higher CO_2CO ratios and excess air use to burn a given quantity of coke. Thus the use of semi-synthetic catalysts is many times desirable from a catalyst regeneration standpoint because of more economic use of blower air and carbon burning to a lower level that in turn affects selectivity.

It can be seen from this that each of the modern-day catalysts results in a somewhat different operation due to the effect of the above factors. Silica-magnesia is more closely allied to the natural catalysts except for the narrow pore well separation of the equilibrium catalysts. No doubt it too would regenerate properly if the catalyst pores were large enough to provide easy access for the regeneration gases to flow in and out, and will likely be tried again before too long.

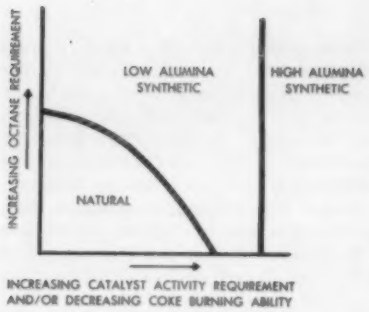


FIG. 2.

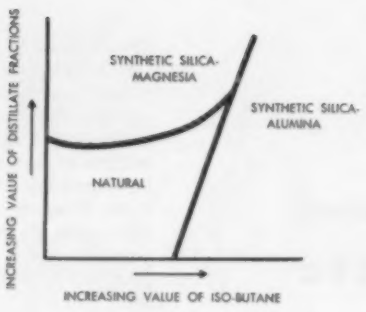
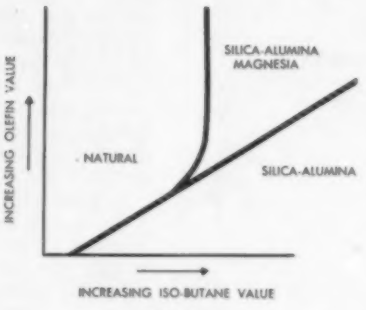


FIG. 3.



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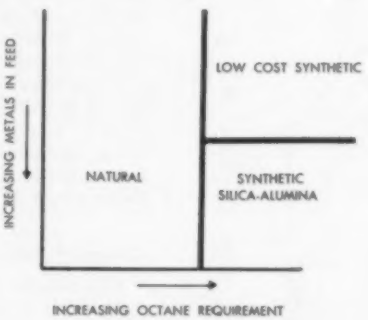

FIG. 5.

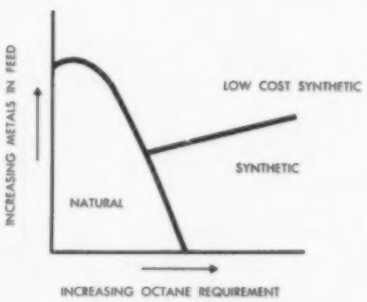

FIG. 6.

Economics — actual choice of catalyst

Of course, the actual choice of catalyst is based on economic considerations. In this section, we will deal with those technical features which, in our experience, have appeared most often to be determinants of catalyst choice. All these factors are, of course, interdependent, but among the most important are factors which relate to the particular cat cracking unit being considered and the methods of operation which can be used in that unit. Since any two cat crackers will be as different as any two people, these factors alone account for much of the variety in choice of catalyst around the world. These factors influence choice of catalyst largely through effects on catalyst properties such as attrition resistance and fluidized bulk density as they influence catalyst use rate required to maintain operation. However, if these factors are influential in catalyst choice, they are usually such as to limit choice of catalyst and narrow the range of possible catalysts. To enlarge the possible choice of catalysts and take advantage of the full range of possible product distributions offered by catalyst manufacturers today, it is desirable for operators to be able to handle a full range of catalyst types. For example, a mode of operation which limits the catalyst type to one which gives equilibrium catalyst in certain ranges of fluidized bulk density can inhibit freedom of choice regarding possible product distribution.

Bearing in mind this reservation that peculiarities of individual cracking units will, to a large extent, influence the rate of catalyst usage and hence the cost of a given catalyst program, we can briefly consider some of the product distribution features which can determine catalyst choice.

Economic considerations will vary so greatly from one plant to the next that a detailed economic analysis would in effect be relevant only for the situation described. However, in what follows, we will draw attention to some features that we believe have proved crucial in actual catalyst choice situations. In any given case, the decision would be based on some combination of all these factors and perhaps others, but it will be more convenient to illustrate some of these effect in a pairwise manner. Similarly the trends indicated will vary in intensity depending on the combinations of other factors involved, and the line of decision can be shifted by the influence of other effects. For example, increased use of lead can make octane less of a factor in the choice of a cracking catalyst.

The equilibrium activity desired is a factor which is always considered. In some cases, satisfactory equilibrium activity can be achieved with low alumina synthetic catalyst. In other cases, high alumina catalyst will be required. At the same time, a requirement for gasoline octane can sometimes be translated into a choice between natural and synthetic catalyst. These considerations are illustrated in Fig. 2.

A requirement for distillate fuels, on the other hand, can tip the balance in the direction of natural catalyst, especially if iso-butane is valued relatively low in the refining situation in question. For example, this could be influenced strongly by the presence or absence of alkylation facilities. (Fig. 3) In our opinion, where isobutane is diverted to alkylation end use the economics are such as to enhance the use of synthetic over natural cracking catalyst.

Restricting consideration to the gas fraction, as the relative values of isobutane and olefins (such as propylene) change choices can also be made from a wide variety of catalyst types. (Fig. 4.)

In referring to the situation where metals contamination of feed has to be counted as effective on optimum catalyst make-up rate and where gasoline octane is significant, other choices become available. (Fig 5)

On the other hand, if we imagine also imposing variations in iso-butane value, then the situation in Fig. 5 might begin to look more like that in Fig. 6, as iso-butane value increases.

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What you should know about

catalytic cracking

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Part 1. Kinetics . . . Catalysis

Part 2. Fluidization

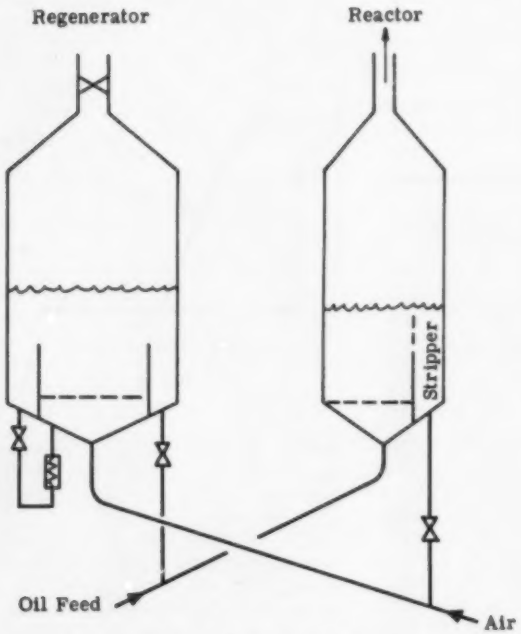

FIG. 2. Catalytic cracking unit, Shell Oil Company, Houston.

PERFORMANCE of the overall catalytic cracking process (cracking-stripping-regeneration) is vitally affected by the catalyst fluidization or flow pattern characteristics and by the gas flow patterns in the fluid catalyst beds. Variations in mechanical design of the reactor, stripper, and regenerator sections of each separate unit as well as in different units can be responsible for differences in catalyst and gas flow patterns. However, in general for commercial operation these differences are more in degree than in absolute type of flow patterns, and it is the general type of flow pattern which primarily influences the over-all performance of the cracking unit. Basically the catalyst and gas flow patterns can follow one of two paths or a combination of the two. In the completely mixed or well mixed case, the entering catalyst and/or gas mixes almost instantaneously with the main catalyst inventory and/or gas volume so that the catalyst and/or gas compositions are the same throughout the entire system. Plug flow is the reverse of this with little or no mixing occurring between the entering streams and the catalyst inventory and/or gas volume. In this case the streams enter at one location and move progressively through the system to the exit as a "plug."

In general the conventional commercial fluid bed catalytic cracking unit may be considered to be operating predominately as a well mixed system both with respect to gas and catalyst flow patterns. Since this flow pattern as compared to plug flow results in a less desirable product distribution and hence less profitable operation for the refiner, considerable effort has been devoted to measuring and understanding the patterns and mechanisms of gas-catalyst fluidization. Gas-catalyst mixing studies carried out in commercial units[43-46] and mathematical treatment of mixing and contacting characteristics[47] have all contributed to a better understanding of performance characteristics of catalytic cracking units. It is now possible to characterize gas-catalyst fluidization mechanics in commercial units and to evaluate, at least qualitatively, how they influence the over-all cracking performance of the unit.

Catalyst flow patterns

The catalyst flow patterns in three commercial units of different designs (Fig. 2 to 4) were determined.[43] The technique used consisted of injecting pulses of catalyst tagged with radioactive scandium-46 and/or cerium-144 into the units at different locations. The degree of spread plus the time required for this tagged catalyst to appear in different sections of the units was a direct measurement of the catalyst flow patterns.

Although the catalyst flow pattern in each of the major vessels of all three units approached reasonably close to a well mixed stage, there were qualitative differences. The stacked-type Shellburn unit appeared to approach most closely to a well mixed catalyst stage in both reactor and regenerator vessels. However, in the Houston unit the catalyst appeared to traverse the system at a faster rate than would be predicted for either the well mixed or plug flow cases. This phenomenon of catalyst bypassing is actually a variant of plug flow since the short circuiting catalyst moves as a small isolated "plug" through the main catalyst bed. For the Houston unit the catalyst bypassing appeared to occur primarily in the reactor-stripper section and not in the regenerator. In the Norco unit, the catalyst required a longer time to circulate through the system than would be predicted for the well mixed case. This was apparently caused by a definite catalyst circulation pattern in the regenerator bed.

The method of catalyst entry into the catalyst bed influenced the catalyst flow pattern.[43] The use of a riser with the attendant low catalyst density increases the probability

of some catalyst short circuiting the main bed. Conversely, the use of a standpipe with the attendant high catalyst density minimizes the possibility of this catalyst bypassing. Lastly, the flow of catalyst in a vessel will approach plug flow if baffles are installed in the horizontal plane. This is exemplified by the strippers on the Norco and Shellburn units.

Gas flow patterns

Gas flow patterns have been determined for the regenerators of three commercial fluid bed catalytic cracking units. The regenerator instead of the reactor was studied because of the obviously greater convenience and ease of sample handling. However, the same general trends except as limited by mechanical configuration differences should be applicable to both the reactor and regenerator. In general it appears that the gas mixing characteristics in fluid beds more closely approach the well mixed case as contrasted to plug flow.

The work of Askins, Hinds, and Kunreuther[44] indicated that the gas flow in the interstices of the catalyst closely approached a well mixed flow pattern. Gas samples extracted from various locations in the regenerator [40-ft diam by 15-ft (above cone) catalyst bed] of the catalytic cracking unit of a Houston, Texas, refinery, were analyzed for carbon dioxide, carbon monoxide and oxygen. The essentially constant composition of the gas samples extracted from different sections of the fluid bed was indicative of very rapid and complete gas mixing throughout the interstices of the catalyst bed. In addition, a rapid sampling technique (10 sec duration) permitted obtaining gas samples which were more indicative of "spot" gas compositions in the bed than the normal average samples taken over a 5 to 10-min interval. Comparison of the gas compositions obtained by these two techniques suggested that an appreciable fraction of the total gas probably passed through the bed in the form of bubbles or cavities.

The degree of gas mixing under both steady state and nonsteady state conditions using helium tracer gas was studied by Handlos, Kunstman, and Schissler[45] for the 41-ft diam regenerator at the Dominguez refinery of Shell Oil Company, Wilmington, California. The air to the regenerator is supplied at three different locations with about 70% being added with the spent catalyst through the transfer line (this is distributed into the bed at the top of the cone) and the remaining 30% through two aeration rings located in the cone. For the tracer tests, helium was added to the regeneration air. The steady state test (i.e., continued addition of helium to the unit during the test period) indicated varying degrees of gas mixing in different sections of the over-all catalyst bed. The gases in the center and middle sections of the cone and in the center section of the main catalyst bed above the cone appeared to undergo less mixing than did the middle and outer sections of the main catalyst bed. For this latter case, the gas mixing patterns approached the complete mixing case. At the end of each steady state test (end of admission of helium to the system) a nonsteady state or transition period test was started. This consisted of measuring the helium concentration in the gas phase at a point 4 ft above the catalyst bed. In contrast to the conclusions drawn from the steady state tests, these nonsteady state or transition type tests were indicative of essentially complete gas mixing throughout the entire catalyst bed.

A third set of gas mixing pattern data was obtained earlier by Danckwerts, Jenkins and Place[46] for the 40-ft diam regenerator at a refinery in England. Their tests were made under nonsteady state conditions and used pulses of helium as a tracer gas. Unfortunately certain limitations imposed by the test conditions made analysis of these data difficult. Nevertheless, a re-evaluation of these data by Handlos and

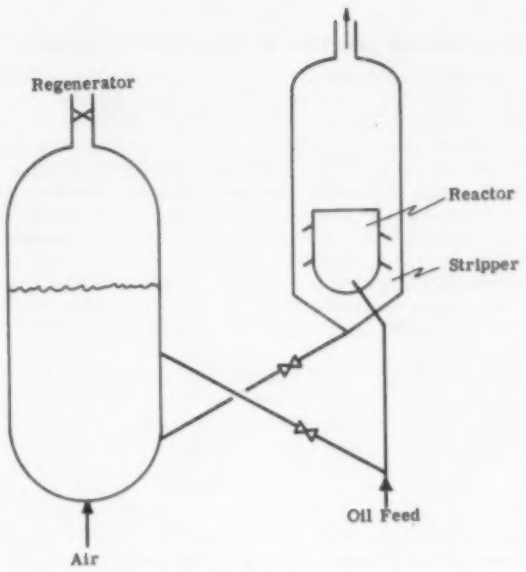

FIG. 3. Catalytic cracking unit, Shell Oil Company, Norco, Louisiana.

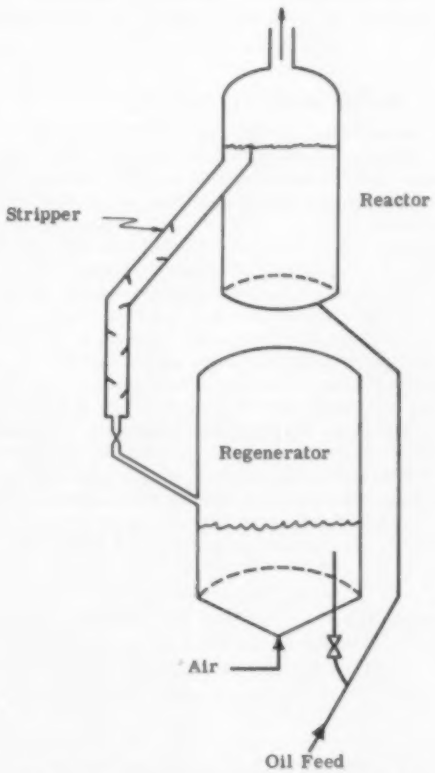

FIG. 4. Catalytic cracking unit, Shell Oil of Canada, Shellburn (Vancouver), British Columbia.

co-workers[45] using their Dominguez data as a guide suggested that the gas flow pattern in the Stanlow catalyst bed approached the completely mixed case.

Mathematical analysis of gas-catalyst mixing

Mathematical treatment of gas-catalyst mixing in large scale commercial vessels must take into consideration radial mixing effects in addition to the gas eddy diffusivity rate in the catalyst interstices and the rate of gas mass transfer between the "bubbles" or "cavities" and the dense phase. The gas eddy diffusivity rate and gas mass transfer rate parameters can be conveniently reduced to mathematical terms; however, the radial mixing parameter is somewhat complicated and cannot be readily incorporated in the mathematical model. For this reason mathematical analysis of gas-catalyst mixing patterns is usually restricted to bench-scale tests where large length to diameter ratios minimize radial mixing.

A mathematical analysis of gas-catalyst mixing characteristics has been reported by van Deemter.[47] The model used in this analysis was based on two separate phases, namely, a dense catalyst phase of low average gas velocity and a dispersed catalyst phase of high average gas velocity. There was continuous gas and solids exchange between the two phases as the result of disintegration of the dense phase and coalescence of the dispersed phase solids. Mathematical expressions were derived for gas back-mixing and for the standard deviation of the gas residence time distribution. Further, the extent and importance of the gas eddy diffusivity rate of the dense phase and the rate of gas mass-transfer between the two phases was discussed. The interested reader is referred to the original article[47] for the mathematical details.

Effects during catalytic cracking

The performance of the commercial catalytic cracking unit is strongly influenced by the gas-catalyst mixing characteristics in the major vessels. A fluid bed in which the gas and catalyst streams are in plug flow rather than the completely mixed state operates at a high degree of efficiency. The primary mechanism which influences the efficiency of operation is the extent of secondary reactions which occur in the reactor. Secondary reactions are defined as the additional reactions which cracked products (i.e., gasoline) undergo leading to the destruction of gasoline to lower boiling and less valuable products and to added coke make. Although secondary reactions continually occur in fluid bed cracking, the mechanics of plug flow are directed toward minimizing them whereas the mechanics of completely mixed flows tend to promote them. Since the gas and catalyst flows in both the reactor and regenerator approach the completely mixed state, it is of interest to examine each aspect of the mechanics of mixed flows so as to evaluate at least qualitatively their effects on the over-all catalytic cracking operation.

Reactor. The close approach to complete vapor mixing in the reactor catalyst interstices, as described above, must result in nearly uniform concentrations of reactant (feed) and products in the catalyst bed. Since this results in a whole spectrum of feed stock-catalyst contact times, it is apparent that at any average conversion level, various portions of the total feed will have undergone different extents of conversion. This nonuniformity in conversion levels for various portions of the feed stock is undesirable because the undercracked portions (short residence time) do not contribute their fair share of the desirable cracked products whereas the overcracked portions (long residence time) fall prey to secondary reactions with the attendant loss in gasoline yield and increase in coke make.

Two other factors to be considered are related to effective cracking severity in the reactor. First, the uniformity of vapor composition (cracked products and unconverted feed stock) in the catalyst interstices results in a lower partial pressure for the unconverted feed stock than would be obtained in the nonmixed or plug flow case. Second, the well mixed catalyst bed is representative of an entire spectrum of catalyst ages. This results in a lower average catalyst activity than is obtained in the nonmixed or plug flow case. Since both of these factors tend to decrease effective cracking severity, it is necessary to increase the apparent cracking severity (i.e., lower space velocity) for the completely mixed case as compared to plug flow operation in order to reach the same average conversion level. This creates added opportunities for secondary reactions to occur with the attendant degradation in product yields.

A final aspect of gas-catalyst fluidization characteristics which influences product distribution is the tendency of a portion of the feed stock to pass up through the catalyst bed in the form of "bubbles," or "cavities." There is probably little interchange between the vapors in the "bubbles" and in the catalyst interstices.[44] Although a "rain" of catalyst undoubtedly passes through the "bubbles," this portion of the feed stock remains at a lower conversion level than the average of the main portion of the feed stock in the catalyst interstices. This nonuniformity in conversion level for different portions of the total feed stock again contributes to the promotion of secondary reactions as discussed above.

Many suggestions have appeared in the literature for improving the gas-catalyst flow characteristics in large diameter fluid beds. Among these are baffling the fluid bed with either perforated discs[48] or such packing as Raschig rings or Berl saddles,[49] compartmenting the fluid bed so that it is effectively subdivided into many separate and discrete stages, and lastly the use of multistaging to accomplish the

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over-all reactions in two or more separate operations. Of these possibilities only the last one has been successfully carried out on a commercial scale.

Shell Oil Company refinery at Anacortes, Washington, has placed into highly successful operation the first commercial two stage catalytic cracking unit.[15] The principles utilized to improve product distribution over that obtained in a conventional type single stage unit are twofold.

First, the total cracking step is subdivided into two separate stages with interstage fractionation. This permits cracking the easily cracked portion of the total feed under relatively mild conditions. The interstage fractionator then removes the cracked products before the unconverted gas oil enters the second stage where more severe cracking conditions are employed. This staging sequence decreases secondary reactions and improves product yields by decreasing the total contact time the cracked products are in contact with the catalyst and by permitting more uniform conversion of the total feed.

Secondly, a novel design first stage reactor consisting of a dilute phase riser with gas and catalyst in concurrent upward flow is used. The gas-catalyst flow in the riser reactor approaches the nonmixed or plug type flow with the attendant decrease in secondary reactions and improvement in product distribution. A further aspect of the dilute phase riser type reactor is that operations can be carried out at relatively high temperatures and short contact time — factors which improve product distribution.

The marked improvement in product yields that can be realized from drastic reductions in secondary reactions is illustrated by the data[15] in Table 2. At a fixed coke make, the improved operating mechanics of the two stage process as compared to single stage cracking permits operations at a significantly higher conversion level and gasoline yield.

Table 2. Single Stage and Two Stage Cracking of West Texas Flashed Distillate.[15]

	Single Stage		Two Stage
CFR*	1.0	1.6	1.6
Temperature, F	900	900	1000/900
Conversion, %v	58.5	66.0	72.1
C_5 –450 F Gasoline, %v	35.8	44.9	48.2
Coke, %w	5.2	5.2	5.2

*Ratio of total feed to fresh feed

Regenerator. On the regenerator side, the essentially complete mixing of the catalyst and gases in the fluid bed has two primary adverse effects. First, the complete mixing of the catalyst in the fluid bed results in a "regenerated" catalyst inventory which compasses the entire spectrum of catalyst ages and hence coke burnoff. This means that some catalyst is returned to the reactor before its full activity is restored whereas other catalyst remains in the regenerator beyond the time required for coke burnoff. The net effect is that the catalyst returned to the reactor is less active than would be realized from better gas-catalyst fluidization characteristics. Second, the complete mixing of gases in the catalyst interstices together with the bubble formation phenomenon results in a significantly lower average oxygen partial pressure than would be realized if the gas flow approached plug flow characteristics. This in effect increases the average catalyst residence time required in the regenerator to accomplish a given coke burning rate.

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data from U.S. refiners that withdraw synthetic FCC catalyst

Average and spot information for 1st Quarter, 1960

Refiner	Type of Catalyst, % Al_2O_3	Fresh Feed Rate, B/SD.	Addition Rate, T/SD.	Addition Rate, Lbs./Bbl. F.F.	Stack Losses, T/SD.	Withdrawals, T/SD.	Withdrawals, Wt. % of Additions	Catalyst Quality: Metals, Wt. % V	Ni	Cu	Fe	Na_2O	Activity, D+L	Surf. Area, $M^2/GM.$	Pore Volume, CC/GM.
A	25	3,780	1.30	0.69	0.50	0.80	62	.0462	.0424	.0007	.99	.04	25	142	.45
B	25	28,000	3.00	0.21	2.13	0.87	29	.0385	.0325	.0002	.86	.06	32	155	.52
C	25	13,100	4.00	0.61	3.50	0.50	13	.0342	.0039	.0005	.12	.03	34	146	.48
D	25	28,000	3.00	0.21	2.00	1.00	33	.0077	.0028	.0001	.31		28		.34
E	25	8,000	0.80	0.20	0.40	0.40	50								
F	25	43,000	7.00	0.33	4.00	3.00	43								
G (2)*	25	60,000	10.00	0.33	7.50	2.50	25								
H	13	4,250	0.53	0.25	0.46	0.07	13	.0671	.0304	.0008	1.22	.03	26	125	.46
I	13	12,500	1.00	0.16	0.80	0.20	20	.0309	.0271	.0002	1.39	.02	30	147	.42
J	13	4,800	0.90	0.38	0.76	0.14	16	.0580	.0128	.0013	1.02	.03	31	127	.51
K	13	9,600	0.77	0.16	0.37	0.40	52	.0079	.0234	.0002	.61	.09	31	146	.44
L	13	8,250	2.70	0.65	2.30	0.40	15	.0360	.0330	.0002	.22	.03	31	184	.45
M	13	8,000	0.65	0.16	0.45	0.20	31	.0207	.0053	.0001	.68	.12		151	.41
N	13	7,500	1.00	0.27	0.75	0.25	25	.0247	.0127	.0002	.40	1.68	25		
O	13	14,000	3.00	0.43	1.65	1.35	45	.0206	.0143	.0001	.23	.09	30	125	.39
P	13	5,000	0.60	0.24	0.50	0.10	17	.0208	.0060	.0001	.34	.02	30	134	.39
Q	13	21,000	2.30	0.22	2.00	0.30	13	.0104	.0129	.0001	.25	.04	29	122	.22
R	13	8,000	1.20	0.30	1.00	0.20	17	.0260	.0089	.0003	.18		32		
S	13	20,000	4.50	0.45	3.50	1.00	22	.0230	.0090	.0001	.20	.05	28	91	.34
T	13	7,500	0.95	0.25	0.50	0.45	47	.0139	.0027	.0002	.35	.05	33	149	.40
U	13	14,000	1.50	0.21	1.00	0.50	33	.0134	.0054	.0001	.31	.04	35	160	.49
V	13	7,000	1.12	0.32	0.77	0.35	31	.0064	.0028	.0001	.34	.02	31	141	.43
W	13	28,000	4.50	0.32	3.50	1.00	22	.0054	.0019	.0006	.34	.14	29	105	.37
X	13	22,600	4.70	0.42	2.50	2.20	47	.0095	.0018	.0002	.17	.14	30	118	.39
Y	13	2,200	0.12	0.11	0.07	0.05	42								
Z	13	4,500	0.75	0.33	0.18	0.57	76								
a	13	3,530	0.50	0.28	0.30	0.20	40								
b	13	13,500	1.00	0.15	0.70	0.30	30								
c (2)*	13	9,500	0.50	0.11	0.40	0.10	20								
d	13	39,000	3.00	0.15	1.50	1.50	50								
e	13	9,000	1.25	0.28	0.75	0.50	40								
f	13	7,000	0.40	0.11	0.30	0.10	25								
g	13	7,000	1.00	0.29	0.20	0.80	80								

*=No. of FCC units in total figures.

NOTES:

1. Blank spaces indicate data not available.
2. "Catalyst type" refers to the material used during the period covered, and may not be the same as the unit inventory.

A 1st quarter '60 survey . . .

Why refiners withdraw catalyst

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HERE ARE RESULTS of a survey that answers the question of how much catalyst people are using and why. This is a question every operator of a catalytic cracking unit has probably asked at one time or another in an effort to compare and evaluate his own usage. Specifically, some engineers want to know how many refiners add just enough catalyst to balance stack losses. Others want to know how many actually add more catalyst than their unit losses, while purposely withdrawing catalyst to maintain unit inventory, and why do they do this.

To answer these questions, a survey was conducted of units operating in the United States during the first quarter of 1960. There were 126 fluid catalytic cracking units in operation. Of these units . . .

- 86 were using all synthetic catalysts
- 49 were on low alumina
- 37 were on high alumina

The remaining 40 units operated primarily on semi-synthetic catalyst, synthetic and natural mixtures, and a few on natural alone. For this study, we limited the investigation to synthetic users.

Of the 86 synthetic users, 41 added only enough catalyst to maintain unit inventory, while 45 purposely withdrew catalyst. Of the 45 that withdrew catalyst, we had accurate operating information on 35. Also, we do equilibrium catalyst analyses for 21 of these 35. The information basic to this investigation is shown in the opposite table.

Refiners who add only enough catalyst to balance stack losses do so because they are running a very clean feed stock, or because they do not require a high catalyst activity, or because stack losses are normally high anyway. Conversely, the tabulated data indicates refiners withdraw catalyst for one of two reasons:

1. **They can show a definite yield (dollar) advantage for operating at higher catalyst activity than the minimum set by stack loss (0.20 lb per bbl F.F. for the 35 units covered).**
2. **They must add excess catalyst to maintain required catalyst activity and selectivity in the face of highly contaminated feed stocks.**

Most refiners questioned believe that they should add more catalyst than required to maintain unit inventory. They base this belief on yield advantages shown in pilot plant studies for operating at high catalyst activity. Unfortunately, these advantages are not easily demonstrated on a commercial unit because of difficulties in maintaining steady state conditions. ★ ★ ★

Part 1. General process design relationships.

Part 2. Applied process and mechanical design procedures.

Moving bed catalytic cracking

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PART 1 OF THIS ARTICLE dealt with fundamental mechanisms underlying the process design of the principal components of a moving bed catalytic cracking unit, namely . . .

- Gravitating flow of solids
- Flow of vapors through solids beds
- Heat transfer between gases and solids

Part 2 presents process design procedures for specific elements of the HB Houdriflow unit which illustrates the application of these fundamental mechanisms. For simplicity, the design procedures do not include all of the detail customarily employed in commercial practice.

Top seal leg design

Process design of the top seal leg, which operates with an adverse pressure gradient, involves establishing the length of leg required to maintain catalyst flow against reactor pressure, the diameter required at the base of the leg for design catalyst flow, and the degree of taper needed to maintain an approximately constant pressure gradient along the leg as the static pressure decreases. The theoretical maximum adverse gradient for a vertical leg is about 9 in. water per ft. The limit for inclined legs is lower, depending, in addition, on the angle of inclination and the coefficient of friction, as follows:

$$\text{Max } \Delta P/\Delta L = \rho\,(\sin\theta - \mu\cos\theta)\,(\sin\theta) \quad . \quad . \quad . \quad (4)$$

where $\Delta P/\Delta L$ = Gradient, lb/ft²/ft of projected vertical height

ρ = Flowing bulk density of catalyst, lb/ft³

θ = Angle of inclination from horizontal

μ = Coefficient of friction, catalyst-to-catalyst at a free surface

Because of the importance of continuous stable operation of this leg, a more conservative design limit on pressure gradient is usually fixed at 6 in. water per ft for vertical lines and at correspondingly lower values for inclined lines. Fig. 11 shows the nominal design values for inclined seal legs. Since sealing capacity decreases rapidly with decreasing θ, it is generally not economic to design reactor seal legs for inclination angles less than 75 deg.

Diameter at the bottom of the seal leg is determined from the data of Fig. 8 and 12, which is a plot of a specific example of the equation for catalyst flow capacity of pipes. The leg is tapered to compensate for the change in seal gas density resulting from the reduction in static pressure along its length, in order to maintain a nearly constant pressure gradient. To determine the taper, the quantity of seal steam required to develop the selected gradient at the bottom of the seal leg is first calculated from Fig. 9. Then, diameters which result in the same gradient are calculated at spaced intervals up the leg. Dimensions of the actual taper can now be determined by plotting theoretical diameter versus length and approximating this curve as closely as possible with one or more straight lines representing the tapered sections. Usually, two tapered sections are required to hold the variation in pressure gradient to 2 to 3% of design although short legs can be fitted with a single tapered section.

Reactor oil feed system

The design of this system is the result of extensive experimental work. The total hydrocarbon charge is introduced into the reactor through a single mixed-phase nozzle. The nozzle is a simple device, consisting of a pipe section with inclined internal half-diameter baffles which impart a centrifugal motion to the vapor and liquid. The liquid portion of the feed is discharged from the periphery of the nozzle in a uniform hollow conical spray which disperses into minute droplets in the vapor stream as it travels to meet the surrounding catalyst curtain.

Developmental work has shown that superficial nozzle vapor velocities in the range of 40 to 70 ft per sec are optimum from the standpoint of generating a good spray pattern without disrupting the catalyst curtain. For satisfactory distribution of liquid on the catalyst curtain, the liquid loading should not exceed 175 bbl per stream day per in. of nozzle periphery. The nozzle size is usually controlled by liquid loading, and vapor velocity is held in the desired range by the addition of steam and/or by the use of a coaxial cylindrical blockout within the nozzle.

The catalyst curtain surrounding the nozzle is formed by a restrictive annular orifice which is sized to pass 80 to 95% of the total catalyst circulation. Capacity plots similar to Fig. 13 are used for this calculation. A relatively thin curtain is desirable for intimate contact of oil and catalyst, while a thicker curtain is more effective in preventing penetration of liquid droplets, some of which may reach the walls of the reactor and subsequently decompose to coke. Catalyst curtain thicknesses ranging from 1¼ in. to 2½ in. are usually optimum. The catalyst orifice and feed nozzle are positioned about 5 to 8 ft above the reactor bed to allow contact and heat exchange before the non-turbulent flow conditions of the bed are reached.

Catalyst and oil feed systems of this design have been employed in all Houdriflow units. Also, several bucket ele-

vator TCC units have been equipped with oil feed systems of this type to handle modest amounts of non-vaporized charging stocks.

Reactor bed design

The volume of catalyst in the reactor bed is determined by the space rate or contact time requirements in conjunction with the other operating variables such as temperature and catalyst to oil ratio. These have been established empirically by pilot plant evaluation of a variety of charging stocks. Normally, provision is made for a range of bed volumes in order to accommodate various operating schemes foreseen by the refiner. The relationships among conversion, product distribution and operating variables have been described by Maerker, et. al.[8]

After the maximum volume has been fixed, the proportions of the reactor bed, i.e., depth and diameter or L/D ratio, are set principally by pressure drop considerations. Since the diameter of the vapor disengaging section is usually the same as that of the reaction zone, a relatively small reactor diameter requires more levels of disengaging with the result that the overall pressure drop is high. Economics generally dictate that the maximum overall reactor pressure drop be held to 4 to 6 psi and a 2 or 3-level disengager be used.

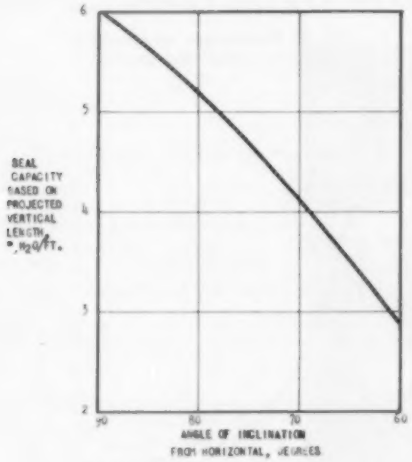

FIG. 11. Seal leg design chart.

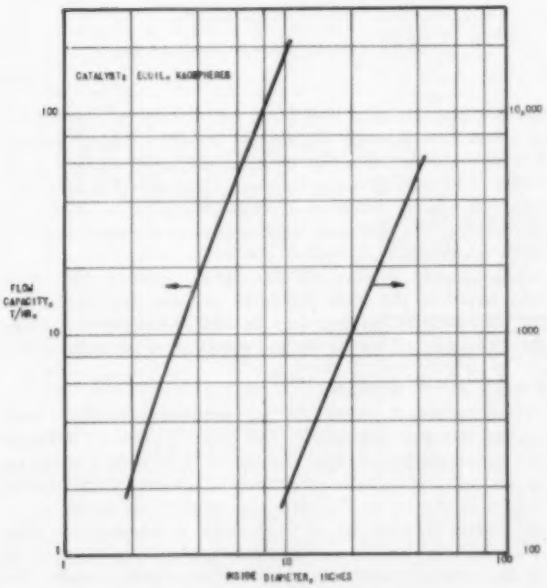

FIG. 12. Catalyst flow capacity of pipes — no pressure gradient.

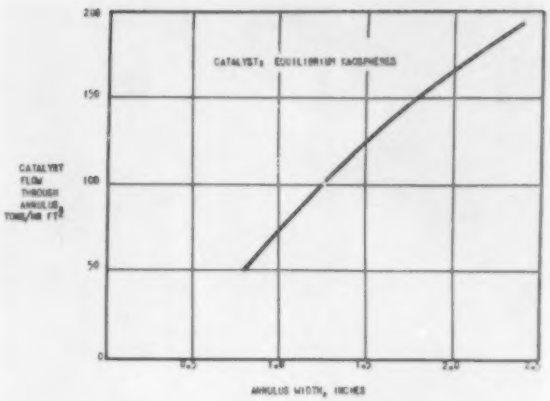

FIG. 13. Annular orifice flow capacity.

Vapor disengager design

The disengaging of synthetic crude vapor is accomplished with a multi-level, channel-type disengager as depicted in Fig. 4. The number of levels of channels depends on whether reactor diameter, as set by reactor bed volume and pressure drop considerations, is large or small in relation to the vapor throughput. Fundamentally, vapor disengaging is accomplished here, as elsewhere in the unit, under conditions of countercurrent vapor and catalyst flow. Flow through the reactor being concurrent, the inverted channels provide free catalyst surfaces throughout the catalyst mass where vapor can reverse direction and disengage from the catalyst.

The quantity of vapor which can be disengaged at each level, i.e., the disengaging capacity of each level, and the method of controlling this quantity are the principal process design considerations of the disengager. The design criteria have been derived from experimental tests on full-scale sectional models, such as that shown in Fig. 14. Although a large variety of channel configurations and orientations have been studied experimentally, the depicted system was found to be optimum with respect to simplicity, capacity, and cost.[9]

In actual performance the distribution of vapor flow in the catalyst bed beneath one of the upper channels is such that a portion of the vapor which enters the channel along the edges reverses direction and returns to the bed below the channel. The extent of this recirculation is related to the pressure gradient within the section of bed below the channel. Thus, the net capacity of an upper channel to disengage vapor is a function of the amount of vapor flowing to the next lower level of channels, although maximum gross disengagement is still determined by the theoretical limits of countercurrent flow discussed previously. Experimentally, the capacity of the disengaging channels, expressed as net "disengaging pressure gradient," has been related to the bed pressure gradient beneath the channels.

A final factor of importance in the process design is the "rise" of catalyst within the inverted channel. As the disengaging load is increased on a channel, the free surface of the catalyst flowing beneath the channel is raised up into the channel by the upflowing vapors. Consequently,

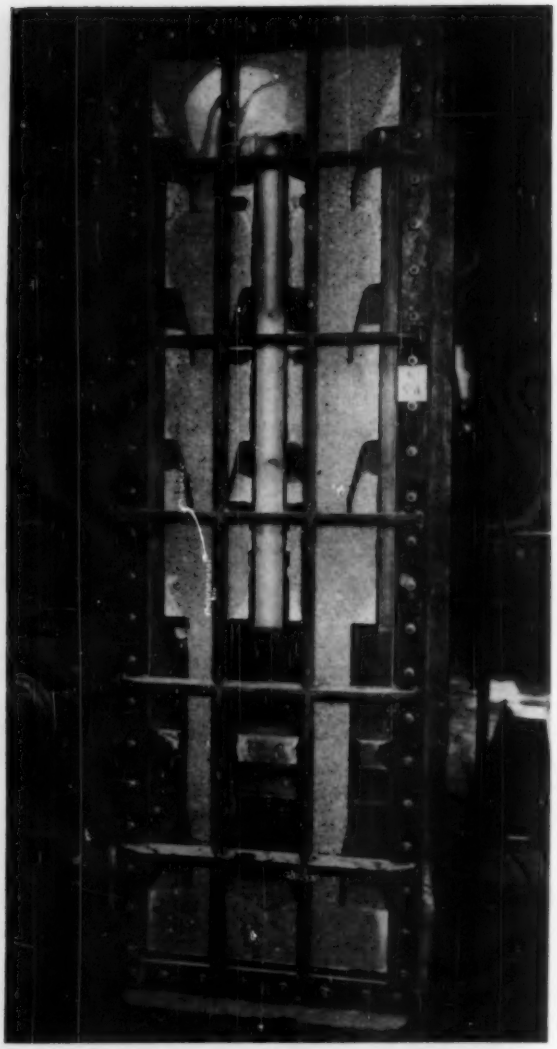

FIG. 14. Houdriflow reactor vapor disengager test model.

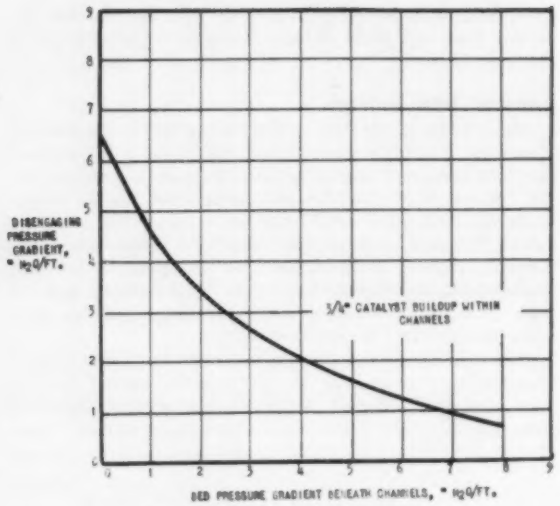
DISENGAGING PRESSURE GRADIENT, " H2O/FT.
3/4" CATALYST BUILDUP WITHIN CHANNELS
BED PRESSURE GRADIENT BENEATH CHANNELS, " H2O/FT.

FIG. 15. Performance of Houdriflow reactor vapor disengagers.

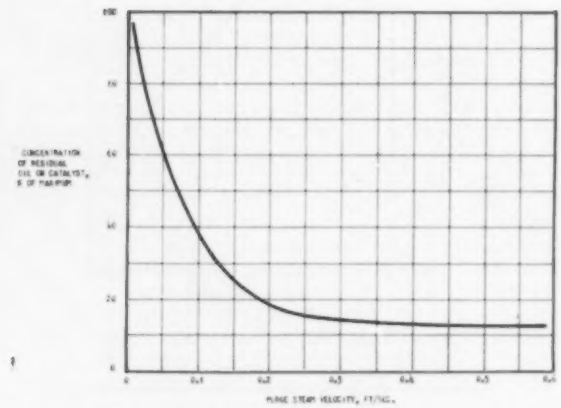

FIG. 16. Design basis for purge section.

the design loading on each channel must be limited to such a value that catalyst is not stagnated or entrained by excessive vapor flow into the vapor collecting tubes.

A typical correlation of these factors is shown in Fig. 15. This curve describes performance at conditions such that the catalyst surface underneath the channel rises ¾-in. inside the channel. Similar relationships exist for conditions which induce higher and lower amounts of catalyst rise. The curves are used as design criteria, with higher loadings being reserved as safety factor to handle pressure surges on the reactor outlet and the usual variations in operating conditions which different processing conditions require.

The maximum allowable disengaging gradient for the bottom or collector channel is set only by the classical force balance since there is no downward vapor flow beneath this channel. To provide some nominal safety factor, a design limit of 5 in. water per ft is generally used to compute the capacity of this channel.

Composite design is developed by computing disengaging gradients and sectional bed pressure drops for each of the successive elements of the assembly, utilizing the conventional vapor pressure drop relationship of Fig. 9 for this purpose. By trial and error calculation, a distribution of vapor flow through the several levels of disengagement is determined so that the entire disengaging section is in proper flow and pressure balance. Physically the flow distribution among levels of disengagement is accomplished by installing appropriately sized orifices in the vertical vapor tubes under each channel.

Disengaging devices of the earlier moving bed units were based on the same principles as those described here, but the assembly employed in the HB unit is superior from the standpoint of simplicity and mechanical ruggedness.

Purge zone design

Function and layout of the purge section has been briefly described previously. The upward pressure differential across the purge pipes is selected to provide a stripping steam velocity which effectively displaces hydrocarbon vapors as shown in Fig. 16. The number of purge pipes, approximately one per sq ft of vessel cross-sectional area, is selected to provide a uniform flow profile at the bottom of the reactor vapor disengager, immediately above. The pattern of purge pipes must meet the criterion of uniform horizontal catalyst flow profile at a reasonable "coning

DU PONT *Petroleum Chemicals* NEWS

Number 105 in a series of bulletins for the Petroleum Industry

NOVEMBER • DECEMBER 1960

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gives America the BIG picture on travel

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The music rises, and a title sweeps across the wide Cinemascope screen: "Down the Road."

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"Down the Road" is a color Cinemascope movie. Sponsored by Du Pont, it will be distributed on an international basis by 20th Century-Fox, starting with theaters all across America in December. This distribution will provide the oil industry with a *broad* "expand the demand" promotion. As such, it affords *your* company a natural backdrop to your own travel development activities.

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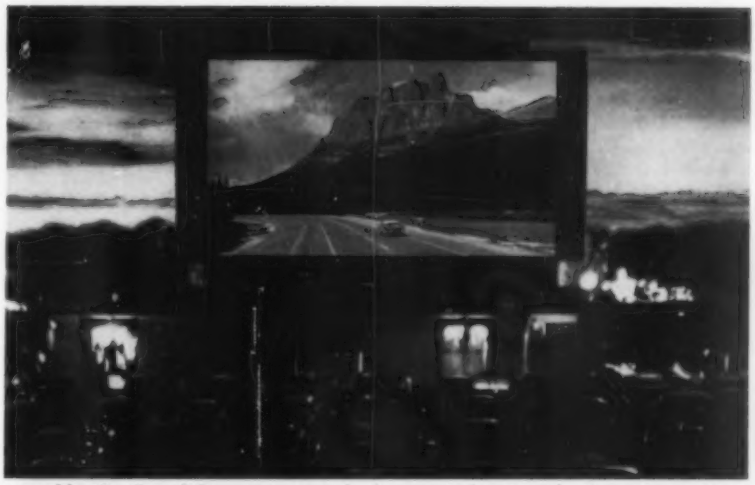
In production for a full year and shot entirely on location – "Down the Road" will encourage a greater appreciation of the heritage and beauties of America, and stimulate public interest in seeing them firsthand through the convenience and comfort of the family car.

The movie is a fast-moving panorama that sweeps all the way from snow-capped peaks along the Alaskan Highway to sun-capped skyscrapers in Manhattan, from popular vacation



spots like the Grand Canyon to out-of-the-way lakeside camp sites, from the excitement of a Mardi Gras to the thrill of a county fair.

"America is a land as close to home as the point of view, and as far away as a thousand horizons." This narrative in the film points out that today's highways make *all* America our playland – to see, to admire, to cherish. But there's more than just scenery in this film. Woven into it are strong messages on safe driving, and for keeping the trip completely enjoyable with the help of America's network of service stations.

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W. A. TAFT, Director of Sales of the Du Pont Petroleum Chemicals Division, explains the purpose behind Du Pont's sponsorship of the film "Down the Road."

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CONTINUED *Why Du Pont Sponsored "ROAD"*

W. A. TAFT, Director of Sales, Du Pont Petroleum Chemicals Division

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PHILADELPHIA DISTRICT MANAGER

CARL W. FERRIS became manager of the Du Pont Petroleum Chemicals Division's Philadelphia District in July of 1959.

Mr. Ferris has exceptional experience and qualifications for helping refineries in his district, in the use of TEL, TML, Du Pont TETRAMIX antiknock compound and other additives.

He joined the Du Pont Company in 1947, and his first assignment was at the Du Pont Petroleum Laboratory, where he worked on fuel blending studies in the single cylinder engine laboratory. He then did road test work with the Du Pont fleet of fuel test cars. He was transferred to the Division's central region in 1951, where he served, successively, as regional automotive service representative, sales promotion coordinator, an account manager, and manager of the Chicago District.

Prior to his present position, he was on special technical and planning assignments in Wilmington.

A graduate of Cornell University, Mr. Ferris has a Bachelor of Mechanical Engineering degree. During World War II, he served nearly three years in the U. S. Navy and held a commission as Lieutenant, jg. He is a member of the Society of Automotive Engineers.

His main interests outside the office are gardening and woodworking. Carl is married and the father of two young girls.

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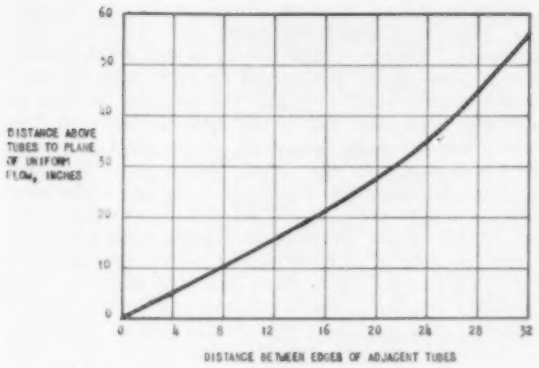

FIG. 17. Catalyst coking height above tube sheets.

height" as depicted in Fig. 17. This curve illustrates the typical variation in the angle of internal friction of flowing bulk solids. Withdrawal points must be located sufficiently close together that all adjacent flow cones intersect a short distance above the tube sheet.

Reactor-kiln seal section

The function of the reactor-kiln seal section is to prevent a flow of hydrocarbon vapors from the reactor into the top of the kiln as a consequence of a differential pressure of about 6 psi between these two locations. The seal pipes are designed for a downward pressure gradient of approximately 20 in. water per ft so that the pressure breakdown is accommodated with seal pipes 9 to 10 ft in length. Part of the steam introduced at the purge section flows downward through the seal pipes to provide the sealing medium. This design criterion for the seal legs provides for a modest consumption of sealing steam. Moreover, the use of concurrent pressure gradients in excess of 30 in. water per ft is generally not recommended because of its adverse effect on the character of catalyst flow.

Seal pipes are arranged in a concentric circular pattern in such a way that the upper end of each pipe is positioned midway between two consecutive purge pipes in the tube sheet above. There are exactly half as many seal pipes as purge pipes. Frequently the diameter of the kiln is larger than that of the reactor and in such instances the straight seal pipes are sloped radially outward so as to provide a symmetrical transition from the smaller to the larger cross-sectional area.

Kiln design

The regeneration system involves several process design considerations:

1. **Regeneration** must be controlled so that temperatures do not reach the point where serious thermal deactivation of the catalyst occurs. For modern moving bed cracking catalyst this point is in the region of 1450F. In the HB Houdriflow design the catalyst circulation rate, and hence the catalyst to oil ratio, is fixed at such a value that combustion of the coke on the spent catalyst is not great enough to raise the catalyst temperature above a design maximum of approximately 1300 F, based on an average heat balance and average operating conditions. A typical value for coke concentration on the spent catalyst is 1.0 wt%.

In calculating the kiln heat balance, the coke is customarily assumed to be 95% carbon and 5% hydrogen. The CO_2/CO ratio in the exiting flue gas is about 2 in a single zone kiln with the newer catalysts. The specific heat of a typical catalyst over the range of 900F to 1300F averages 0.3 Btu/lb/F. Since heat exchange between catalyst and vapor is extremely rapid and plug-type flow prevails, the incoming cold regeneration air is heated to the maximum catalyst temperature within a few inches of the level of air engagement.

2. **Volume of the kiln** must be sized for a catalyst residence time adequate for complete combustion of the coke, i.e., a residual carbon concentration of 0.1 to 0.2 wt%. Investigation of the regeneration mechanism has led to basic burning rate data for coke deposits on various commercial catalysts and the relative effects of such variables as coke concentration, temperature, and oxygen partial pressure.[10] For kaolin catalyst, the burning rate is first-order with respect to both carbon concentration and oxygen partial pressure. The effect of temperature on burning rate is shown in Fig. 18.

In calculating burning volume, sectional heat and material balances are made for the combustion of successive increments of the coke deposit to determine oxygen partial pressures and temperatures for each increment. Instantaneous burning rates are then determined for the terminal

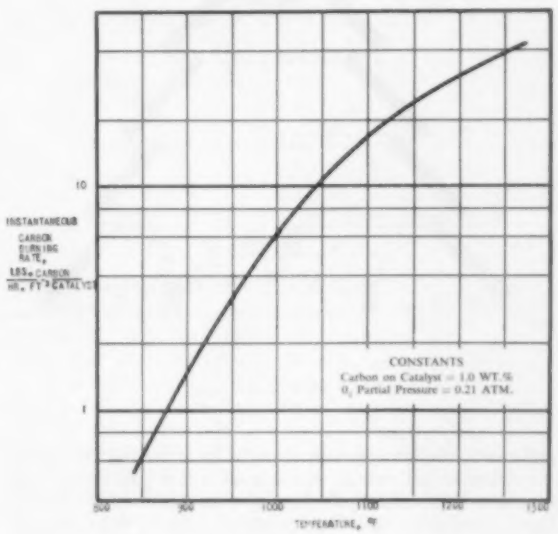

FIG. 18. Kaolin catalyst regeneration rate data.

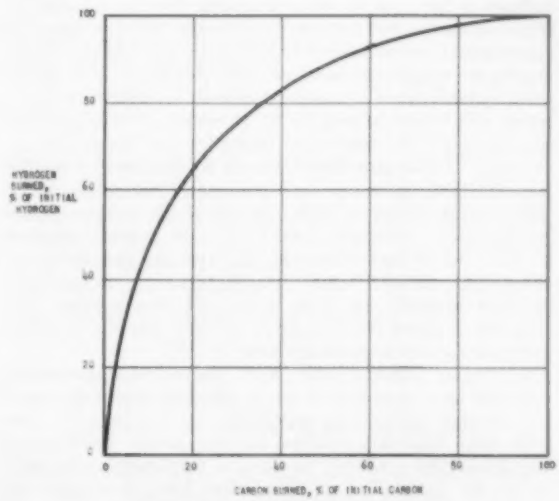

FIG. 19. Relative hydrogen and carbon burning rates in catalytic coke.

conditions of each increment. The theoretical burning volume is obtained through a graphical integration of a plot of reciprocal burning rate vs coke burned. The installed volume should include a safety factor because of the importance to the cracking process of obtaining complete removal of the coke deposit even though the coke yield should deviate from the design value by a modest amount.

It should be noted that combustion of hydrogen is much more rapid than combustion of carbon, as shown by the relationship in Fig. 19. Thus, at the top of the kiln, much of the heat of combustion results from burning the hydrogen in the coke.

3. **Proportions of the kiln,** i.e., diameter and depth, should be such that at conditions of maximum air flow the pressure drop through the kiln will be low enough to permit the use of a single stage centrifugal air blower with a discharge pressure rating of 5.5 to 6 psig. The

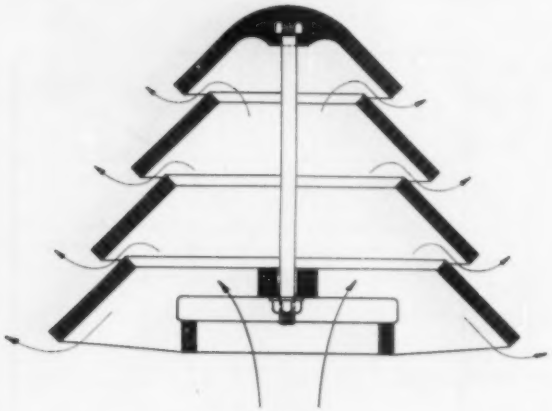

FIG. 20. Kiln air cap.

optimum relationship can usually be achieved by fixing the diameter at a value which gives a flue gas disengaging gradient at the top of the bed of 6 in. water per ft. Under these conditions the kiln pressure drop will usually be about 4 psi.

4. **Regeneration air** must be introduced and catalyst must be withdrawn uniformly over the cross-section of the bottom of the kiln in order to derive the full benefits of true countercurrent flow of catalyst and air. Considerable experimental work has been done on devices for introducing or "engaging" kiln air. The one which was found most suitable from a structural as well as a process standpoint, and which is used on all Houdriflow kilns, is called an "air cap." It consists of multiple cone frustrums decreasing in diameter from bottom to top as depicted in Fig. 20. This assembly rests on an air riser pipe in the bottom kiln tube sheet. The capacity of the caps to engage gas has been related experimentally to the pressure gradient in the catalyst bed above the cap and the bed cross-sectional area served. Normal design is to use at least one air cap assembly per 4 sq ft of kiln cross-section. The caps are disposed in a concentric circular pattern to obtain symmetrical coverage of the bed.

In bucket elevator TCC kilns the air was distributed over the kiln cross-section via inverted channels. Although the channel system was acceptable for use in TCC kilns with their relatively shallow burning zones, problems of expansion and inherent mechanical weakness made them unsuitable for the larger Houdriflow kilns operating with deep beds and at higher temperature levels.

Catalyst is withdrawn from the kiln through a series of pipes located on the same circles as the air engaging caps, withdrawal pipes alternating with air caps. The diameters of the pipe circles are set so that the successive annular areas of the kiln served by each circle of pipes are in the ratio 1:3:5:7:9: etc. The numbers of pipes in successive circles are also in this ratio so that each pipe draws from the same proportion of the total kiln area. The withdrawal pipes run radially into a group of nested concentric funnels whose lower ends terminate at the same elevation within the kiln catalyst outlet line. The lower ends of the funnels are carefully designed and fabricated so that the annular sections formed are again in the ratio of 1:3:5:7:9:etc. Catalyst flows down the outlet line with a uniform velocity profile and consequently catalyst flows uniformly through each of the annular sections formed by the concentric funnels. Thus, each section flows catalyst at a rate in proportion to the area of the kiln served by the circle of withdrawal pipes feeding it. The kiln air inlet and catalyst withdrawal system is shown in more detail in Fig. 5.

Catalyst lift system design

Fig. 21 shows the principal elements of the catalyst lift engager. It consists of three concentric pipes, the innermost pipe being the lift itself and the outermost forming the shell of the engager vessel. The middle pipe separates catalyst, flowing downward in the inner annulus. The annular passages for lift gas and catalyst flow are sized for velocities of about 50 ft per sec and 0.5 ft per sec, respectively.

Ability of primary lift gas to entrain catalyst is directly related to the clearance for gas flow between the bottom of the lift pipe and the surface of the catalyst bed below. For a given engager this is determined by the difference in elevation between the bottom of the lift pipe and the bottom of the pipe surrounding it. This dimension, commonly called the "gap," is generally in the range of ½ in. to 1½ in. In operation, the rate of catalyst entrainment, and hence catalyst circulation rate, is varied by injecting small amounts of steam into the catalyst bed at the bottom of the lift engager. The effect of this bed steam is to raise the profile of the catalyst surface beneath the lift pipe in proportion to the steam flow rate, making it easier or harder for the lift gas to engage catalyst. Proper selection of the "gap" setting will minimize the amount of bed steam needed.

The lower portion of the lift is a straight pipe while the upper portion is a divergent tapered section 75 to 100 ft long. Commercial experience with gas lifts of this type have established that optimum performance is usually achieved with mass flow rates of 35 to 45 lb/sec/ft² and maximum catalyst velocities of 45 to 70 ft per sec.

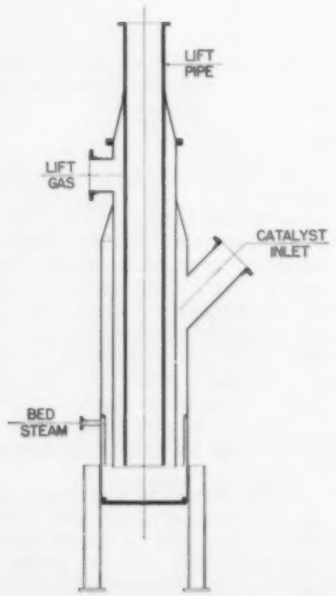

FIG. 21. Lift engager.

With part of the lift design set empirically, the remaining process considerations are the rate and pressure at which the lift gas must be supplied. Following a discussion of gas lift fundamentals, calculation of the gas rate and pressure drop are explained.

Basic concepts of gas lift design

If a solid particle is introduced into a body of fluid at rest, the particle is subjected to three forces: gravity, buoyancy, and drag. The force of gravity tends to accelerate the particle toward the center of the earth; the buoyant force tends to accelerate the particle away from the center of the earth; and the drag force tends to decelerate the motion of the particle relative to the fluid. The drag force is utilized for the transportation of catalyst in dilute phase gas lifts. The buoyant force can be neglected, since catalyst pellet densities are at least 1000 times as large as the density of the lifting medium.

Two basic concepts used in lift design are slip velocity and equilibrium slip velocity. Slip velocity is defined as the difference between the fluid and catalyst velocities. Restated, the fluid velocity is the sum of the slip velocity and catalyst velocity. Equilibrium slip velocity is attained when there is no net driving force to accelerate the catalyst. In a lift pipe, equilibrium slip velocity is never quite attained, since the fluid density decreases and, therefore, fluid velocity increases with the change in static pressure from the bottom to the top of the lift. For all practical purposes, however, catalyst and fluid are in equilibrium in the upper portions of the straight section of the lift.

Equilibrium slip velocity is the same as the particle supporting velocity (fluid velocity required to support a catalyst pellet at rest in a moving gas stream) and the terminal velocity in free fall. This velocity can be calculated from the properties of the solid and the fluid by the following equation:

$$U_{s_{eq}} = K\sqrt{\frac{g\ D_p\ \rho_p}{\rho_f}} \quad . \quad . \quad . \quad . \quad (5)$$

(See Table 1 for nomenclature)

Table 1. Nomenclature of Gas Lift Design.

- U = Actual velocity, ft/sec
- K = Constant dependent on particle shape = 1.7 for KAO-SPHERES
- g = Acceleration of gravity
- D = Diameter, ft
- ρ = Density, lb/ft^3
- E = Fractional void volume
- C = Solids concentration in lift, lb/ft^3
- V = Average velocity, ft/sec (superficial for gases)
- G = Mass rate, lb/ft^2/sec
- Δ = Difference, finite
- P = Pressure
- L = Length, ft
- d = Differential operator

Subscripts

- s = Slip (gas relative to solids)
- p = Particle
- f = Fluid
- c = Solids

Secondary Subscript

- eq. = Equilibrium

The supporting velocity (equilibrium slip velocity) presented in Equation 5 was derived for a single pellet suspended in a gas stream and is not strictly valid for a system involving many particles. The amount of gas required to support many particles is a function of the concentration of these particles. The concentration of particles reduces the effective cross-section for gas flow. The fractional void content is determined from the density of the particles and the particle concentration in the lift by the following equation:

$$E = \frac{\rho_p - C}{\rho_p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Therefore, the superficial velocity required for particle support is expressed as:

$$\frac{V_f}{E} = U_{s_{eq}} = U_t \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Based on the above definitions the following generalized expressions are used to define lift performance:

At equilibrium

$$U_f = U_{s_{eq}} + U_c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

At any point in lift

$$U_f = U_s + U_c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$G_c = CU_c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\frac{V_f}{E} = U_s + U_c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$G_f = V_{tf}\rho_f \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Characteristics of lift operation

When catalyst is introduced into the gas stream at the bottom of a lift, the transfer of momentum from the fluid to the catalyst is not instantaneous. Some portion of the lift is traversed by the catalyst before it approaches its equilibrium velocity. Note that this is a dynamic equilibrium because conditions are continually changing due to the progressive decrease of static pressure of the gas as it flows up the lift. However, the pressure drop is not large and in the straight section of the pipe the catalyst motion can be considered to be always at equilibrium with the gas after initial equilibrium velocity has been achieved.

The top sections of commercial lifts are normally tapered to reduce exiting catalyst velocities by reducing the gas velocity. Due to its momentum the catalyst decelerates much more slowly than the gas. And again, as at the bottom of the lift, catalyst and gas are not in equilibrium motion. In the taper, the catalyst velocity is greater than the equilibrium value while at the bottom of the lift the catalyst velocity is less.

Lift pressure drop considerations

Theoretically, the pressure drop from the bottom to the top of a dilute phase gas lift depends upon the following factors:

1. Static head due to catalyst
2. Static head due to fluid
3. Change in momentum of the catalyst
4. Change in momentum of the fluid
5. Gas-wall friction
6. Solids-wall friction

When the total lift pressure drop is, for example, 3 to 4 psi, the pressure drop due to static head of fluid, change in momentum of fluid, and solids-wall friction is generally less than 0.1 lb per sq in. in commercial gas lifts. The pressure drop due to gas-wall friction is normally 0.1 to 0.2 lb per sq in. Thus, these are minor contributors to lift

pressure drop, the major factors being static head of catalyst and change in momentum of the catalyst. By combining these factors the following equation for lift pressure drop is obtained.

$$\Delta P \text{ total} = \int_{\text{Bottom}}^{\text{Top}} C\, dL + \int_{\text{Bottom}}^{\text{Top}} \frac{G_c}{g}\, dU_c \quad . \quad . \quad . \quad (13)$$

The following equation has been developed to relate pressure gradient at any point in the lift to catalyst concentration and the ratio of actual to equilibrium slip velocity:

$$\frac{dP}{dL} = C\left(\frac{U_s}{U_{s_{eq}}}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad (14)$$

The general expression for pressure gradient is the differential of Equation 13:

$$\frac{dP}{dL} = C + \frac{G_c\ dU_c}{g\ dL} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

The following equation can be obtained by dividing Equations 14 and 15 by concentration and equating the results.

$$\frac{\frac{dP}{dL}}{C} = 1 + \frac{U_c\ dU_c}{g\ dL} = \left(\frac{U_s}{U_{s_{eq}}}\right)^2 \quad . \quad . \quad . \quad (16)$$

or rearranging,

$$dL = \frac{U_c\ dU_c}{g\left[\left(\frac{U_s}{U_{s_{eq}}}\right)^2 - 1\right]} \quad . \quad . \quad . \quad . \quad (17)$$

These relationships are entirely fundamental in character and may be applied to both straight and tapered lift pipes. It should be noted that in taper calculations the catalyst velocity is assumed to be in equilibrium at the base of the taper, and that dU_c is a negative number.

Combining Equation 17 with the basic Equations 5 through 12 allows rigorous point to point solutions of changes in catalyst velocity, concentration, and pressure drop to be made by trial and error. The calculation is made by determining the incremental length required to increase or decrease the catalyst velocity a small amount. From the solution of the equation the catalyst concentrations at various levels are obtained by dividing the catalyst mass rate by the catalyst velocity. The pressure gradient at each level is calculated by Equation 14.

By plotting Dp/DL vs L and graphically integrating, the theoretical pressure drop can be determined.

The foregoing calculation is tedious and is normally used only when point conditions of catalyst velocity and concentration are to be determined. The calculation has been correlated for design purposes in graphical form for most of the conditions encountered commercially. This correlation, Fig. 22, is for the straight section of the lift pipe. Pressure drop in the tapered section is relatively lower because of pressure recovery due to catalyst deceleration, averaging 0.4 to 0.6 psi for an 85 ft long taper.

Actual pressure drop measurements are in good agreement with theoretical values for small diameter lifts and for larger pipes at low concentrations and high velocities. At other conditions in larger pipes the actual pressure drop may run 30 to 40% greater than calculated by this method. This is not particularly inconvenient in using the relationships for design and operations control since the customary engineering practice of employing a correlating factor may be followed.

MECHANICAL DESIGN ASPECTS

It is beyond the scope of this article to discuss in any detail the significance of the mechanical design of the various features of an HB unit. Information of this nature for the earlier Houdriflow designs has been presented in the literature[9-11] and a great deal of it is applicable to the HB unit also. Some generalizations regarding the physical arrangement of the HB unit will be mentioned along with some comments concerning materials of construction.

The kiln-reactor section of this unit is an integral, self-supporting cylindrical structure. In some installations the reactor surge hopper is also part of this structure, whereas in others the lift disengager and surge vessel is supported by the access structure. While the internal simplicity of the reactor and single zone kiln has been emphasized from a process standpoint, this is equally significant from the standpoint of mechanical design. Only a few internal tube sheets are required to separate process zones. Characteristically these tube sheets are dished heads. This type of construction is not only economical with respect to steel usage but also provides for easy extrapolation of vessel diameters for installations of large capacity. The alternative of flat tube sheets supported by beams becomes unwieldy as vessel sizes are increased.

Most of the elements of the HB unit are fabricated from carbon and low chrome steels. The low chrome steels, up to 1¼

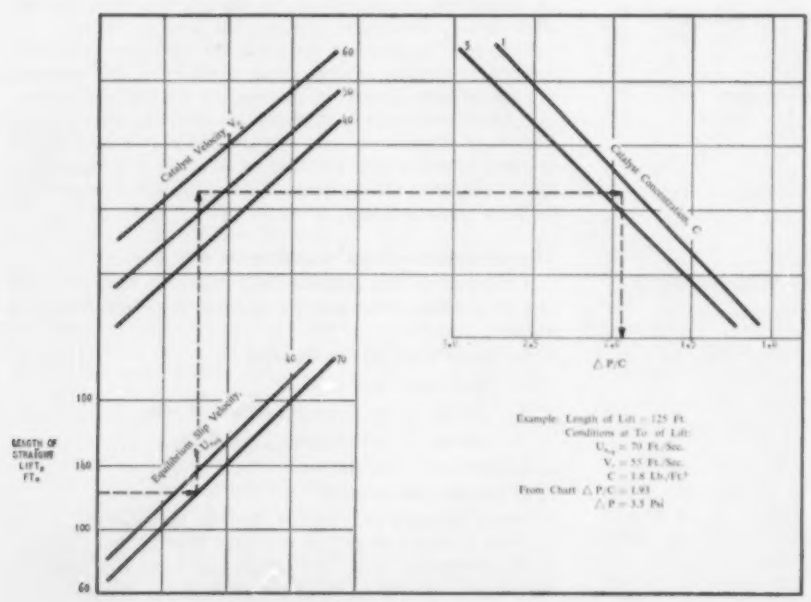
Catalyst Velocity U_s
Catalyst Concentration C
Equilibrium Slip Velocity $U_{s_{eq}}$
LENGTH OF STRAIGHT LIFT, L_s FT.
$\Delta P/C$
Example: Length of Lift = 125 Ft.
Conditions at Top of Lift:
$U_{s_{eq}}$ = 70 Ft./Sec.
V_s = 55 Ft./Sec.
C = 1.6 Lb./Ft.³
From Chart $\Delta P/C$ = 1.93
ΔP = 3.3 Psi

FIG. 22. Generalized correlations for theoretical pressure drop in straight lift pipes.

Cr-½ Mo, are used wherever they are more economical than carbon steel because of load and temperature conditions. Some 12% chrome steel is used for sulfur corrosion resistance in the reactor and a relatively small amount of 5 Cr — 1½ Si is used because of the oxidation resistance in some parts of the kiln. A typical distribution of steel requirements by type is as follows:

	% of Total Weight
Carbon and Low Chrome	80
Stainless (12 Cr)	12
5 Cr 1½ Si	8

The entire kiln-reactor shell, all tube sheets and heads, and the entire lift system are fabricated from carbon or low chrome steels. The reactor shell generally is clad with 12 chrome. The reactor oil feed assembly, the reactor vapor disengager and other reactor internals are also made of 12 chrome plate. This use of 12 chrome steel is strictly for sulfur protection and not because of load conditions. The catalyst tubes and withdrawal section at the bottom of the kiln, being subjected to rather severe oxidizing conditions, are fabricated of 5 chrome-1½ silicon steel which possesses exceptionally fine resistance to oxidation at elevated temperatures.

The entire kiln shell, kiln bottom head, reactor shell above reactor inner head, and reactor top head are internally insulated. Both suspended tile and monolithic insulation have been used satisfactorily in this service. The design kiln shell temperature is approximately 250 F with a transition between cold and hot shell occurring at the level of the kiln-reactor seal tubes. External insulation starts at this point and extends to the top of the vessel. This is generally a blanket-type insulation covered with a metal jacket for weatherproofing.

OPERABILITY AND CONTROL

Authorities generally agree that simplicity of control is one of the distinguishing characteristics of the moving bed catalytic cracking systems.[6,12] The gravitating flow of catalyst through the reaction zones, the relatively long catalyst cycle time, and the simple pressure balance relationships throughout the system combine to provide this inherent advantage for the moving bed systems. A brief review of the operating characteristics of the HB Houdriflow unit will illustrate this claim.

Temperature control in the reactor

A measurement of the reactor temperature is very conveniently managed by recording the temperature of the reaction mix vapors as they leave the reactor. Because of the plug-type flow there is a vertical temperature gradient in the reactor bed due to the endothermic heat of reaction. Obviously, then, the reaction mix temperature is not the mean reactor temperature. However, it is truly an average outlet temperature and provides a convenient and completely satisfactory control point. A good rule of thumb is that the reaction mix temperature plus 20 F equals the mean reactor temperature. Conventionally this temperature is maintained by manual resetting of the temperature controllers on the charge heater and the air line burner.

Temperature control in the kiln

Only one temperature in the kiln is important for operating control, that being the average maximum burning temperature measured at or near the bottom of the single burning zone. One or more multi-point thermowells are installed in a horizontal plane near the bottom tube sheet of the kiln for this purpose. Although there are modest variations in the horizontal temperature profiles at this location, reflecting less than perfect distribution of flows and burning patterns, an adequate operating control may be established in any of several ways. One technique has been to wire in parallel the several thermocouples in one plane by means of which one average temperature is measured. Another concept widely used is to record the readings of one or more thermocouples that are measuring the peak temperatures in the horizontal profile. This enables the operator to monitor a sampling of the higher temperatures in the burning zone and control these within predetermined acceptable limits. In either instance the temperature profiles result from the catalyst and reactant flow distribution inherent with the system and once established do not vary markedly from day to day. Consequently, the desired temperature profile in the kiln is readily maintained by manual control of the firing of the air line burner and regulation of the regeneration air flow.

Afterburning

In connection with kiln operation, it is important to comment on the matter of "afterburning," a phenomenon familiar to the operators of all catalytic cracking systems. Expressed in simple terms, "afterburning" is the spontaneous ignition of carbon-monoxide in a flue gas stream leaving a regenerator or kiln. It occurs when there are sufficient concentrations of carbon monoxide and oxygen in the flue gas to support combustion and the bulk temperature of the flue gas stream is at or above a threshold ignition temperature of perhaps 1000 F. This problem has been completely circumvented in the HB design. Normally the HB kiln is operated with less than 1% oxygen in the flue gas leaving the top of the burning zone, and this will prevent afterburning by oxygen starvation. However, even if conditions are such as to allow a higher concentration of oxygen in the flue gas, the temperature of the flue gases will seldom exceed 900 F, well below the ignition temperature for afterburning. This advantage is a natural consequence of two phenomena, the plug-type flow of catalyst and vapors in the kiln and the very rapid rate of heat exchange between gas and solid throughout the burning zone. In other words, the flue gases leaving the top of the burning zone will always be in temperature equilibrium with the incoming catalyst, and as a rule of thumb, at a temperature approximately 15 F lower than the reactor hydrocarbon outlet temperature.

Internal pressure balances

The pressure drop relationships in the reactor-kiln section are an integral part of the basis of design of the internals of the unit. These are at play in such a way that little or no pressure instrumentation is required. Normal variations in pressure in the hydrocarbon feed or product fractionation equipment have no effect on the circulation of catalyst and stability of the system. Reference to Fig. 2 will be helpful in appreciating the following remarks on this subject.

The function of the reactor top seal leg has been previously described. It is sufficient to state here that catalyst will flow uninterruptedly down the seal leg at any reactor pressure up to the absolute maximum for which the seal leg was designed. Normally there is sufficient safety factor incorporated with the design of the seal leg that fairly substantial pressure surges in the fractionation and gas plant system can be absorbed without disrupting catalyst flow in the seal leg. No control devices are required.

The seal section between the reactor and kiln functions in a similar manner in that the differential pressure between reactor and kiln may vary from zero to plus 8 or 9 psi without any disruption of catalyst flow. Naturally the flow of sealing steam down the legs varies with the differential pressure, but even this variable is a modest one since the flow rate is approximately proportional to the square root of the differential pressure. The reactor may be bypassed abruptly without any effect on catalyst flow through the system or the pressure balance in the kiln.

The pressure profile in the kiln and lift system is also inherently stable. A pressure gradient from the bottom to

the top of the kiln is established by the geometry of the burning zone and the utilization of a single stage, centrifugal blower, with the top of the kiln operated at or near atmospheric pressure. Correspondingly the pressure drop from the bottom to the top of the lift system matches closely that of the kiln. In other words, the lift disengager is vented to the atmosphere and the pressure at the base of the lift is close to that at the bottom of the kiln so that pressure balancing between outlet of the kiln and the inlet of the lift is not critical. The catalyst transfer line between the kiln and the lift engager functions naturally as a seal for the modest differential pressures which may exist here.

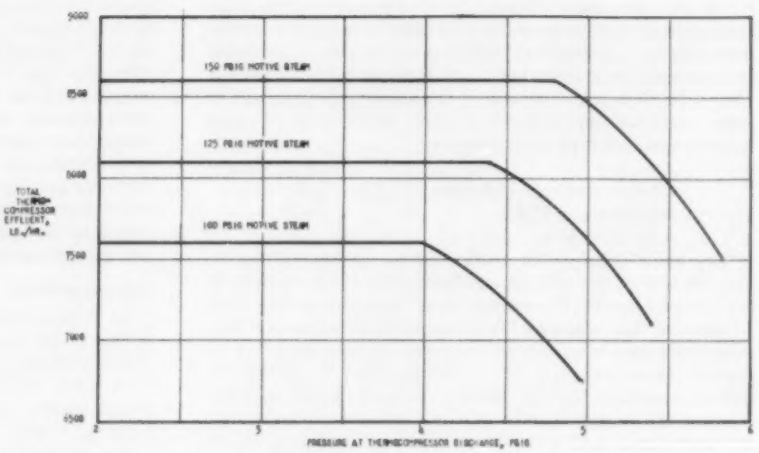

FIG. 23. Typical thermocompressor performance curve.

Control of the gas lift

It is appropriate to comment briefly on the simplicity of the control system for the gas lift utilized in the HB unit. As stated elsewhere, the lift gas is delivered to the lift engager at the required pressure by a thermocompressor which generally utilizes nominal 125 lb steam as the motive fluid. The thermocompressors for this service are designed to have a "flat" characteristic curve over a range of discharge pressures as illustrated in Fig. 23. The advantage of this characteristic of the jet is evident when one considers that a change in velocity in the lift pipe is associated with a change in pressure at the bottom of the lift, other conditions remaining constant. For example, a reduction in velocity causes a slight increase in pressure. If lift gas were supplied from a centrifugal machine, such a disturbance in the system would tend to reduce the flow of gas with a further increase in pressure at the base of the lift and so on. On the other hand, the flat characteristic of the thermocompressor guarantees that an increase in pressure at the base of the lift will not change the rate of flow of lift gas. Thus, the jet has a stabilizing influence on lift operation. In addition, the thermocompressor is an excellent metering device. From the calibration curve and the observed motive steam pressure and flue gas temperature the operator may read reliably the lift gas flow rate.

Heat balance

When the "coilless" HB Houdriflow unit was offered to the industry, some reservations regarding the operability and maneuverability of the process were expressed. From a lay view this is a logical question in view of the fact that all moving bed catalytic cracking units built prior to 1960 were equipped with some kiln cooling coils for removal of a portion of the regeneration heat. To forego this means of regulation of the system heat balance, however, is not as serious as it might seem at first glance. A review of the role played by kiln cooling coils in the earlier Houdriflow designs is enlightening on this score.

While the term "heat balanced" has been applied to the "coilless" kiln design to differentiate it from its predecessors, this is ambiguous, to say the least, because all continuous catalytic cracking systems obviously operate in heat balance. As coke production varies on any catalytic cracker, the overall heat balance is maintained by adjustment of heat input and output at any of several locations in the system. Furthermore the heat removed from the system by the cooling coils of a typical Houdriflow unit is only a minor portion of the total heat output. For example, on a typical commercial installation the total heat released by combustion of coke is 185 MM Btu's per hr, and the heat removed from the system by kiln coils is 35 MM Btu's per hr. Thus 80% of the heat released by combustion of the coke is used to satisfy sensible heat requirements of the reactor and miscellaneous heat losses. On the same unit a charge preheater with a duty of 78 MM Btu's per hr adds heat to the system. In effect, all the heat going to steam generation in the kiln coils is supplied by the charge preheater. In any case, the cooling coil duty is not the major factor in the overall heat balance. Furthermore, the frequent adjustment of coil duty has never been condoned as an appropriate means of adjusting the system heat balance for modest variations in coke load. Regulation of the other sources of heat input and output is the preferred method of heat balance control of moving bed units, even those equipped with kiln cooling coils.

The means available for momentary regulation of the overall heat balance of the system are suggested by the operating conditions listed in Table 2. The tabulated data depict hypothetical situations for a typical unit in which the reactor charge rate remains constant but, because of variations in quality of the charge, the coke load varies from 20% below to 20% above the nominal design value. Naturally many other permutations could be hypothesized but this simple sequence will serve to illustrate the adequate flexibility of the design.

The matter of heat balance regulation may be generalized as follows. If the heat released from coke burning is greater than needed for heat balance, the system can be brought into heat balance:

1. By reducing the firing of the charge preheater.
2. By decreasing the firing of the airline burner.

Table 2. Heat Balance Summaries.

	Design	80% of Design Coke	120% of Design Coke
Coke, lb/hr	7,280	5,840	8,720
Total reactor charge, bpsd	18,800	18,800	18,800
Air rate, lb/hr	88,000	80,000	118,000
Air temp., F	150	800	150
Reactor outlet F	860	900	860
Total heat in feed, MM Btu/hr	124.2	136.8	113.0
Feed enthalpy, Btu/lb	511	563	465
Feed condition			
Temp. F at reactor	665	720	625
Vaporization %	67	83	45
Cat. circ. rate, ton/hr	360	388	432

3. By increasing the flow of cold air to the kiln.
4. By increasing within modest limits the total charge rate to the reactor. (The latter is most conveniently achieved by increasing the recycle rate although the use of extraneous charge stocks is equally acceptable.)

If the heat released from coke burning is less than needed for heat balance the required balance can be restored:

1. By increasing the firing of the airline burner.
2. By raising the temperature of the reactor charge leaving the oil preheater.
3. By recycling a small quantity of synthetic crude tower bottoms to the reactor so that coke deposition is preferentially increased to the desired level.

It is important at this point to mention the stabilizing effect of the relatively long catalyst cycle time (approximately one hr) of the Houdriflow system. With a cycle time of this magnitude a modest disturbance to the heat balance does not result in the system spiraling quickly out of control. To the contrary, operating temperatures throughout the system tend to move slowly from the set point and the operator can be very deliberate in deciding upon and making his moves to restore the desired conditions. Compared with the response characteristics of a catalytic cracking system in which the catalyst cycle time may be an order of magnitude smaller than that of HB Houdriflow, this feature looms as a decided advantage in operability.

FLUID VS. MOVING BED TECHNIQUE

In previous sections of this article the distinguishing features of moving bed systems have been described. Some further reflection on this matter will surely lead to the conclusion that a moving bed system has certain unique and novel characteristics which cannot be duplicated by any other type of reactor system.[1] Curiously enough, the catalytic cracking reactions have been successfully accommodated in at least three different types of heterogeneous catalytic systems, namely, fixed bed, moving bed and fluid bed. This may merely signify that the catalytic cracking reactions are not particularly sensitive to the physical conditions under which they are carried out. In any case, each of these three types of reactor systems has advantages and disadvantages with respect to the others when appraised in terms of a given, arbitrary criterion.[6,12] By the same token, the very characteristic which is regarded as an advantage in one comparison can become a disadvantage in another situation. For example, a uniform reaction zone temperature, a characteristic of the fluid system, may be an advantage in one process but a disadvantage in another process where progressive reactions are favored by a temperature gradient through the reaction zone. The important point is that sweeping generalizations of the virtue of one system over another because of any particular design or operating feature peculiar to that system are not valid. At the very least, an appraisal of the composite features of any reactor system in terms of the specific reactions to be carried out must be made if a sound comparison is sought.

The foregoing considerations make it hazardous to attempt any kind of generalized comparison of the moving bed and fluid techniques as applied to catalytic cracking. However, since comparisons of the two techniques are in the final analysis unavoidable, some appropriate remarks will be made. Certainly it is beyond the scope of this article to attempt any quantitative appraisal of the fluid and moving bed systems. However, some qualitative indication of the advantages and disadvantages of various features of each are provided in Table 3.

The plug-type flow of catalyst and reactants in the moving bed system accounts for a predetermined uniform residence time of not only the catalyst but also the reactants in each reaction zone. Likewise all of the recognized advantages of countercurrent flow of reactants and catalyst may be realized. This is of significance in the effective utilization of oxygen in the countercurrent regeneration zone and the efficient stripping of hydrocarbon vapors in the purge zone. Finally, the feature of gravitating solids flow through the entire reaction system provides for a simple, stable circulating system capable of weathering pressure surges and other external disturbances.

MOVING BED CRACKING CATALYSTS

Within the past five years several major improvements have been made in moving bed cracking catalysts. During this period three new cracking catalysts have been commercialized. These are . . .

- **Durabead**
- **Filtrol Grade 110**
- **KAO-SPHERES**

(A fourth new catalyst, Houdry Type 1, is available commercially in Europe.) No detailed comparison of these will be attempted here; instead, a brief discussion of the outstanding characteristics of these modern catalysts as compared to earlier moving bed catalysts will be given.

Perhaps the most important improvement shown by the new catalysts is better thermal and steam stability. Present day units are designed and operated with maximum kiln temperatures 100 F to 200 F higher than was feasible with earlier catalysts, yet the maintenance of a high average catalyst activity has not been impaired. This advance becomes even more significant when one considers that, in addition to operation at higher temperatures, catalyst make-up is considerably less than it was with earlier catalysts.

Another advantage of the new catalysts is vastly increased physical hardness. The use of gas lifts for catalyst transportation in moving bed units and at higher circulation rates requires that the catalyst be rugged. Prior to the advent of the new catalysts, the cost of catalyst make-up due to attrition losses was a significant portion of total operating costs. This is not generally true at the present time. In fact, during the last five years the total market for moving bed cracking catalyst has decreased in spite of an increase in the number of cracking units installed and operating.

Table 3.

Moving Bed (HB Houdriflow)	Fluidized Bed
Distinguishing Features	
1. Catalyst in pelleted form gravitates through reaction zones.	1. Catalyst is finely divided powder which is supported by vapor streams as a simulated fluid.
2. Continuous gas lift for transporting catalyst.	2. Catalyst is transported by process vapors.
3. Plug-type flow of catalyst and reactants in reaction zones.	3. Inherent turbulence of catalyst and reactants in reaction zones.
4. Relatively long catalyst cycle time.	4. Relatively short catalyst cycle time.
5. Low pressure regeneration, 2 to 5 psig.	
Some Process Advantages	
1. Uniform contacting of catalyst and process vapors is achieved.	1. High catalyst circulation rates may be more readily attained.
2. No delicate pressure balances. Reactor may be bypassed without disturbing catalyst circulation.	2. A uniform reaction zone temperature may be maintained.
3. No dust collection devices needed to recover entrained catalyst from effluent gases.	
Some Process Disadvantages	
1. Not as convenient to operate reactor at pressures higher than 15 psig.	1. Catalyst residence time in the reaction vessels is not uniform.
2. Catalyst transportation is not as easily achieved as in fluid system.	2. Purging of spent catalyst prior to regeneration is more difficult than with pelleted catalyst.
	3. System is less stable than moving bed to disturbances in heat balance.

Another virtue of the new catalysts is improved regenerability. This factor, combined with the higher allowable temperature limits, results in increased coke-burning capacity on existing units and permits the economy of constructing smaller kilns on new units.

Particularly noteworthy is one physical characteristic of KAO-SPHERES. As the name implies, they are spherical. Experience has shown that erosion of metal internals is less severe with spherical particles than with the more conventional extruded cylindrical pellets. This fact was recognized soon after kaolin catalyst was commercialized in pellet form and a concentrated effort by Minerals and Chemicals Corporation of America resulted in the development of KAO-SPHERES. At this writing KAO-SPHERES are the only low cost commercially proven, natural clay catalyst available in spherical form for moving bed units.

For rough design calculations, the average physical properties of the new cracking catalyst are given in Table 4. The range noted for each property includes values for both new and equilibrium catalysts of each type. For more detailed information on other physical properties and discussions of catalytic properties refer to articles by Eastwood and Phelan[13] and Beyler, et. al.[14]

INVESTMENT AND OPERATING COSTS

A relationship between coke-burning capacity and erected costs for HB Houdriflow units is plotted in Fig. 24 over the range of 2000 to 30,000 lb/hr of coke. The cost is influenced so strongly by coke-burning capacity that a similar curve for cost vs fresh feed rate cannot be defined unless parameters of conversion level and type of charge stock are included. In general, the total feed capacity in bbl per stream day will be 2.0 to 2.5 times the numerical value of the coke-burning capacity.

Costs shown in Fig. 24 are for the catalytic section only; i.e., they exclude the feed preheater, synthetic crude fractionation and gas recovery. Although the heater outlet temperature will usually be in the range of 675 to 725 F, the preheater cost can vary widely depending on the enthalpy conditions of the fresh feed and the recycle. Many factors, such as the location of the refinery, type of engineering standards, and degree of automation desired by the refiner, can decrease or increase the cost beyond the average values of Fig. 24. The HB Houdriflow unit is approximately 15% cheaper than the previous Houdriflow design which employed kiln cooling coils.

Table 4. Physical Properties of Modern Moving Bed Cracking Catalysts.

Bulk density, kg/l	0.78–1.00
Porosity, vol %	41–53
Pellet density, kg/l	1.22–1.47
True density, kg/l	2.3–2.6
Surface area, sq meters/gm	70–200
Nominal particle diameter, in.	0.12–0.17

Table 5. Typical Direct Operating Costs. (Catalytic Section only including Preheater)

Total Feed Rate	13,500 bbl per stream day		
Coke Burnoff	6,000 lb/hr		
	Net Consumption	Unit Cost	$/Day
150 psig steam, lb/hr	30,000	50¢/M lb	360
30 psig steam, lb/hr	6,000	50¢/M lb	72
Fuel, MM Btu/hr	60	30¢/MM Btu	432
Cooling water, gpm	700	2¢/M gal	50
Electric power, kw	10	1¢/kwh	2
Catalyst, tons/day	1.8	$225/ton	405
Operating labor, men/shift	2½	$3.25/hr	195
Total Direct Costs			1516

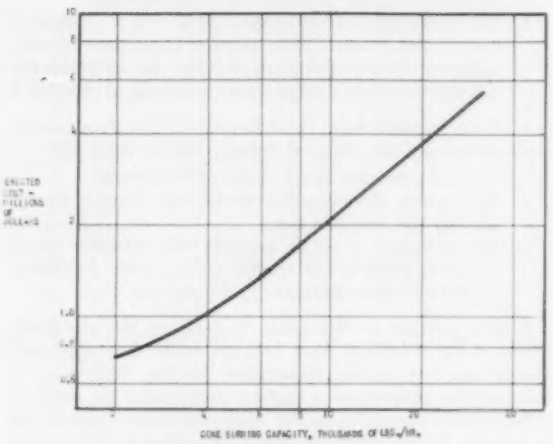

FIG. 24. Erected cost of HB Houdriflow units, catalytic section only.

An analysis of cost estimates for several HB units indicates the following breakdown of the erected cost:

Major equipment material	35 to 40%
Total material	60 to 65%
Total field labor	12 to 14%
Other charges and profit	25 to 21%

Material costs include shop labor and field labor where installation is normally part of the materials contract. For example, the reactor-kiln vessel is usually purchased on an erected basis.

Typical direct operating costs for an HB unit of modest size are given in Table 5. Power requirements shown are based on driving the regeneration air blower with a condensing turbine. An overall utility balance including the synthetic crude fractionator would show the unit to be in steam balance, assuming that the high level quench heat available on the fractionator is used for steam generation. The 30 psig steam usage in the cracking section can readily be supplied from fractionator pump exhausts.

Acknowledgments

For permission to publish this paper the authors express their appreciation to the Houdry Process Corporation who have authorized the publication as a contribution to the technical literature on petroleum refining, but by so doing are not relinquishing any of Houdry's patent and licensing rights. While most of the data and correlations are Houdry developments, some of the information is from other sources, principally Socony-Vacuum Oil Co.

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PETRO/CHEM

ALGEBRA | part 6

THE REVIEW OF ALGEBRA will be concluded in this article, which discusses permutations and combinations and the basic aspects of infinite series.

I. Permutations and Combinations

The rules of permutations and combinations are frequently useful in experimental design and in the sampling of products for quality control. In sampling items from a large source, the sample is a combination of the items drawn and the order of sampling is a permutation of the items.

A permutation is an arrangement of things taken without replacement and a combination is a group of things without regard to the order in which they are taken.

The two basic rules of permutations and combinations are:

- The number of permutations (arrangements) of n different things taken r at a time without replacement is:

$$P_r^n = \frac{n!}{(n-r)!} \quad . \quad . \quad . \quad . \quad (1)$$

- The number of combinations of n things taken r at a time is:

$$\binom{n}{r} = \frac{n!}{(r!)(n-r)!} \quad . \quad . \quad . \quad (2)$$

As an example of the application of these rules consider this sampling problem:

The number of five-card hands all of one suit that can be obtained from a standard 52-card deck consisting of four different suits is

$$4\binom{13}{5} = \frac{(4)\ (13!)}{(5!)\ (8!)} = 5148$$

The number of five-card hands that be made is

$$\binom{52}{5} = \frac{52!}{(5!)\ (47!)} = 2598960$$

Then the probability of getting a flush on a five-card draw is

$$P(\text{flush}) = \frac{5148}{2598960} = 0.00198$$

That is, the chances of being dealt a flush in the first five cards is approximately 2 in 1000.

An extension of this example to a process problem could be as follows:

There are 52 drums containing gasoline of four different octane numbers. Thirteen of the drums contain gasoline having an octane number of 80, another thirteen contain gasoline with an octane number of 85, thirteen others contain gasoline with an octane number of 90, and the remaining thirteen contain gasoline with an octane number of 95. If five samples are taken from these drums at random, what is the probability of all the samples having the same octane number? Of course, the answer is exactly the same as that of getting a flush in a five-card draw.

J. Infinite Series

The expansion of a function in a power series is a way of expressing an approximation of the function

$$f(X) = C_0 + C_1 X + C_2 X^2 + \ldots \quad . \quad (3)$$

The principle of expanding a function into an infinite series of terms is an important part of modern mathematics and finds wide applications in the fields of calculus and differential equations.

The general form of the expansion given in Equation 3 is that of a Taylor series. Expressions have been developed for the coefficients and the remainder obtained by neglecting terms of the series. There are a number of different series expansions available for use in representing functions over intervals of the independent variables. The applications and limitations of the various methods will be brought out in example problems and in their applications to higher mathematics.

Examples of series expansions of some common functions are:

$$\text{Sin } X = X - \frac{X^3}{3!} + \frac{X^5}{5!} - \ldots \text{ for all } X$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$e^X = 1 + X + \frac{X^2}{2!} + \frac{X^3}{3!} + \ldots \text{ for all } X \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\log (1 + X) = X - \frac{X^2}{2} + \frac{X^3}{3} - \ldots \text{ for } -1 < X \leqslant +1 \quad . \quad . \quad (6)$$

An infinite series is convergent if the sum of the first n terms approaches a limit as n approaches infinity. A series is divergent if the sum of the first n terms does not approach a limit. For example, in Equations 4, 5, and 6, for a given value of X the various power series will converge on the corresponding values of f(X) as more and more terms are considered.

In general, the use of series representations of functions involves determining under what conditions the series will actually represent the function, and estimating the error incurred when the sum of the first n terms of the series is used as an approximation to the value of the function.

K. Mathematical Logic

The fundamental concepts of mathematics have undergone considerable development in recent years and the logical analysis of mathematics is now in a process of vigorous development.

The verification of the laws of algebra is based on the analysis of the logical meaning of the various operations and relations. The idea or concept of a set of objects is of primary importance in modern mathematics. A set or class of objects is defined by a property which each object either possesses or does not possess. The study of sets is based on the fact that they may be combined by certain operations to form other sets, just as numbers may be combined by addition or multiplication.

The study of mathematical logic and game theory has brought about the introduction of new mathematical systems. An example of this is the binomial number system which serves as a basis for the design of many of the modern computers.

PROBLEM 8

Correlation of Process Variables by Statistical Methods

The following pilot plant data were obtained for a catalytic hydrogenation reaction:

Percent Unsaturation in Product Stream	Reactor Pressure psia
y	x
18.0	15
20.0	15
17.5	25
15.0	30
12.5	45
10.0	50
3.0	70
5.0	75

During these runs only the reactor pressure was varied and all other process variables were held constant.

Product quality and design scale-up requirements indicate that it will be necessary to have a quantitative correlation of the effect of pressure on the reaction. From statistical considerations determine the desired correlation.

Solution to October Problem:

Problem 7. Voltage Relationship for a Temperature Sensing Element

The series expansion given in Equation 5 of Part 6 can be used to determine the voltage at 700 C.

$$T = 273 + 700 = 973 \text{ K} \quad . \quad . \quad . \quad (7\text{-}1)$$

$$\frac{V}{4.164} = 1 - \frac{(85.33)}{(973)} + \frac{1}{2}\frac{(85.33)^2}{(973)^2} - \frac{1}{(2)(3)}\frac{(85.33)^3}{(973)^3} + \ldots \quad . \quad (7\text{-}2)$$

$$\frac{V}{4.164} = 1 - 0.0877 + 0.00384 - 0.000112 + \ldots$$

$$\frac{V}{4.164} = 0.9160$$

$$V = 3.814 \text{ millivolts} \quad . \quad . \quad . \quad . \quad . \quad (7\text{-}3)$$

On the basis of these calculations an adequate and relatively simple expression for the emf temperature variation in the temperature range 700 C to 900 C would be

$$V = A + \frac{B}{T} + \frac{C}{T^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7\text{-}4)$$

From previous experience in the laboratory the magnitude of the various constants should be

$$A = +4.164$$
$$B = -355.3$$
$$C = +29620$$

The actual value of these constants would have to be determined for each unit. Equation (7-4) would be useful in making up a direct temperature reading scale to be placed over the potentiometer scale.

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GEOMETRY | *part 1*

FUNDAMENTAL CONCEPT of analytic geometry is that of coordinating numbers with a geometrical object, thereby characterizing the object. For example, the position of a point in a plane is frequently characterized or located by a system of rectangular coordinates. The same point could also be characterized by any one of a number of coordinate systems. The choice of coordinates is arbitrary and is usually made to facilitate the subsequent mathematical operations.

A. Directed Distances

A directed line is one in which all segments taken in one direction are considered to be positive, while segments directed in the opposite way are negative. A thermometer offers a familiar example of a directed line. If the interface of the mercury column rises 10 deg, we say that the temperature change is +10 deg. But if the mercury falls 10 deg, the change is spoken of as being −10 deg.

In the rectangular coordinate system each point has two coordinates, x and y, assigned to it. The directed line segment from the origin to a point is known as the position vector of the point. The numbers x and y are projections of the line segment on the axis of the reference frame. On the other hand, in the polar coordinate system, the distance from the origin or pole to a point is called the radius vector of the point, and the angle between the polar axis and the radius vector is called the vectorial angle of the point.

The extension to three and higher dimensional systems follows directly from the one and two dimension cases. For example, in the spherical coordinate system it is necessary to specify three quantities — length of the radius vector and the two direction angles — in order to characterize a point in space. N-dimensional space, which is a logical extension to the multiple variable case, is known as Hilbert space.

B. Equations and Loci

The locus of a given equation is the geometric figure that represents the points which satisfy the equation. For example, an equation involving two variables is satisfied by combinations of values of the two variables. Each of the pairs of numbers represents a point in a rectangular coordinate system and, when taken together, form a curve or locus of the equation. In this manner it is possible to set up a correspondence between certain geometric figures and equations involving variables.

The fundamental principle of analytic geometry is: *If a point lies on a locus, the coordinates of the point satisfy the equation of the locus and conversely, if the coordinates of a point satisfy an equation, the point lies on the locus of the equation.*

For the most part, analytic geometry deals with three types of problems:

- Given an equation, find the locus of the equation and describe it geometrically.
- Given a locus satisfying a geometric condition, find the equation of the locus.
- Given a correspondence between loci and equations, investigate the geometric properties by use of their equations, or, by using the geometric properties of the loci, determine analytical relations among the variables and their equations.

C. Straight Lines

The equations of straight lines occur quite frequently in the analysis of process and design engineering problems. Any straight line has an equation of the form

$$y = mx + b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where m and b are fixed constants characterizing the line. Equation 1 states that all pairs of numbers x, y which satisfy this equation are the coordinates of a point of the line.

Some useful forms of the equation of a straight line are:

point-slope $\quad y - y_1 = m(x - x_1) \quad . \quad (2)$

slope-intercept $\quad y = mx + b \quad . \quad . \quad . \quad . \quad (3)$

two-point

$$y - y_1 = \left(\frac{y_2 - y_1}{x_2 - x_1}\right)(x - x_1) \quad . \quad . \quad (4)$$

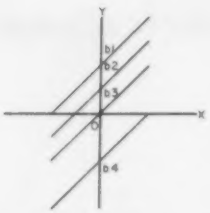

FIG. 1a. Intercept as a parameter.

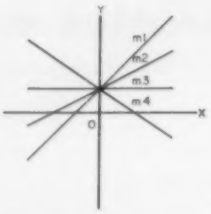

FIG. 1b. Slope as a parameter.

In Equations 2, 3, and 4, m is the slope of the line, b is the y-intercept, and the line passes through points x_1, y_1, and x_2, y_2.

The set of all lines which satisfy one given condition is said to be a system or family of lines. Fig. 1 shows examples of two families of lines. In the first case all the lines have a common slope and the arbitrary constant is the y-intercept. In the second case all the lines have a common intercept and the parameter of the system is the slope.

An alternative method of representing a line by the two-point form is to use the determinant which is equivalent to Equation 4.

$$\begin{vmatrix} x & y & 1 \\ x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \end{vmatrix} = 0 \quad \ldots\ldots\ldots\ldots (5)$$

The fact that Equation 5 is equal to Equation 4 can be established by expanding the determinant by the rules mentioned earlier. This important method of representing equations is particularly useful in multiple variable analysis.

Solution to December Problem:

Problem 8. Correlation of Process Variables By Statistical Methods.

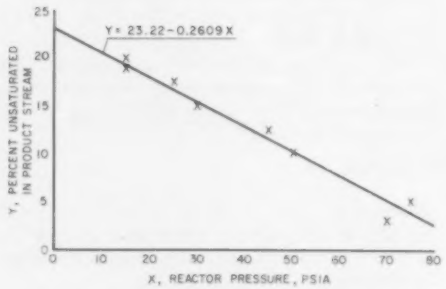

FIG. 2. Effect of pressure on reactor performance.

A plot of the data, Fig. 2, indicates that a straight line correlation is applicable. The relationship can be expressed in the form:

$$y = a + bx \quad \ldots\ldots\ldots (8\text{-}1)$$

The standard procedure for determining the constants in Equation 8-1 is the method of least squares. By this method

$$a = \bar{y} - b\bar{x} \quad \ldots\ldots\ldots (8\text{-}2)$$

and

$$b = \frac{\Sigma (x - \bar{x})\ (y - \bar{y})}{\Sigma (x - \bar{x})^2} \quad \ldots\ldots (8\text{-}3)$$

where the bar indicates the average value.

Applying this method to the eight data points gives

$$\bar{y} = \tfrac{1}{8}\ (18.0 + 20.0 + 17.5 + 15.0 + 12.5 + 10.0 + 3.0 + 5.0) = 12.625$$

Similarly

$$\bar{x} = 40.625$$

Using these values the following table was constructed:

$(y - \bar{y})$	$(x - \bar{x})$	$(x - \bar{x})\cdot(y - \bar{y})$	$(x - \bar{x})^2$
5.375	− 25.625	− 137.73	656.64
7.375	− 25.625	− 188.98	656.65
4.875	− 15.625	− 76.17	244.14
2.375	− 10.625	− 25.23	112.89
0.125	4.375	0.55	19.14
− 2.625	9.375	− 24.61	87.89
− 9.625	29.375	− 282.73	862.89
− 7.625	34.375	− 262.11	1181.64
		− 997.01	3821.88

From Equations 8-2 and 8-3

$$b = \frac{-997.01}{3821.88} = -0.2609$$

$$a = 12.625 - (-0.2609)\ (40.625) = 23.22$$

The best straight line through the data is:

$$y = 23.22 - 0.2609x \quad \ldots\ldots (8\text{-}4)$$

When there is perfect correlation between x and y, there is no deviation between the data and the best line. That the data correlate very well is indicated by the value of the correlation coefficient

$$r^2 = b^2 \left(\frac{\frac{1}{n}\ \Sigma x^2 - \bar{x}^2}{\frac{1}{n}\ \Sigma y^2 - \bar{y}^2} \right) \quad \ldots\ldots (8\text{-}5)$$

For the data of this problem, $r = 0.9806$, which is very near perfect correlation, $r = 1$. Comparison of this value with tables for the probability of a larger value of r reaffirms the excellence of the correlation. The confidence range is also very small for this correlation.

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Design Factors . . .

for lined vessels and piping

Helmut Thielsch, *Metallurgical Engineer*
Grinnell Company, Inc., Providence, Rhode Island

APPLIED LINERS consist of sheets or relatively thin plates bonded intermittently by welding to a backing material, usually carbon or low-alloy steel. Applied liner construction thus combines usually a low-cost carbon or low alloy steel for strength of relatively heavy wall thickness with a high-cost stainless steel or non-ferrous alloy of thin wall thickness.

In most applications liners are selected for their corrosion resistance to environments which would attack mild or low-alloy steel. There are also many applications where applied liners are selected because of their wear resistance, oxidation resistance, heat conductivity, or other characteristics.

Although numerous liner combinations are possible, the greatest tonnage produced involves stainless steel liner materials. In vessels frequently applied liners become more economical than solid stainless steel materials or clad materials in wall thickness exceeding ¾ in. In pressure vessels and tanks of wall thickness above 1¼ in. the attachment of liner plates to the backing steel is likely to be the most economical provided that fabricating and operating conditions permit the use of applied liners.

On pipe where lining methods are somewhat more costly than on large diameter tanks or pressure vessels, it is generally more economical to use solid stainless or other alloy materials. However, there are applications where rather costly materials are required, such as the Hastelloy type alloys. Where this is the case the lining of carbon steel pipe with preformed liner plates will still be more economical than the use of solid Hastelloy piping, Fig. 1. Availability of some of the special alloy metals is also a problem since elbows or other fittings of Hastelloy, Inconel, or other high alloy materials frequently are not readily available. Special fabrication of such shapes would involve considerable time and cost, which might prohibit their use. Lining can be accomplished without delay and often at a significantly lower cost.

In tanks or pressure vessels applied liners are either assembled as plates prior to being formed into special shapes, or the separate backing plate and liner plates are preformed into the final shapes desired and subsequently joined together during fabrication or assembly of the vessel. Pipe or fitting shapes generally employ only the latter method in that the steel pipe or fitting has the applied liner plates welded to the inside of the material.

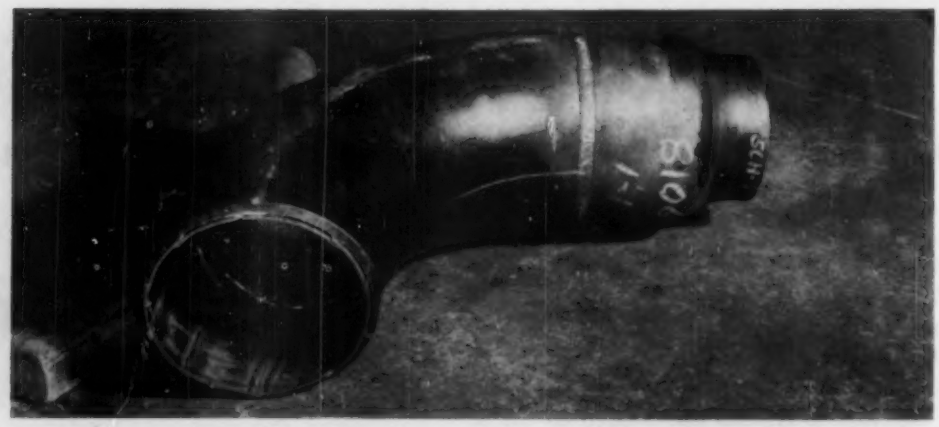

FIG. 1. Elbow and reducer lined with Hastelloy strips.

FIG. 2. Plug welded liner panels being installed (Courtesy American Welding Society).

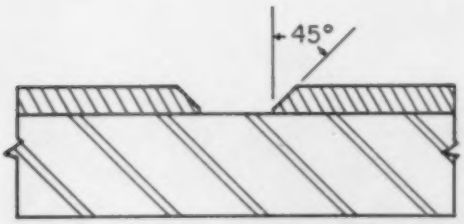

FIG. 3. Bevel preparation for liner plates over 1/8 in. thick.

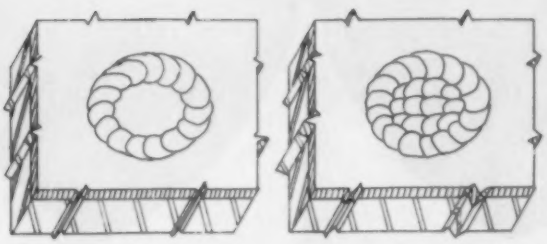

FIG. 4. Ring welding procedure recommended for plug welding by manual shielded metal-arc welding.

Spot or seam welding techniques are generally used where the applied liners are produced first in the form of plates. This represents a shop process requiring costly resistance welding equipment. Only a few large companies have the facilities for the production of lined plates. Arc welding techniques are generally employed when preformed liners are attached to preformed vessel, vessel parts or piping materials.

Lining by arc welding methods is generally done by constructing the whole or part of the vessel or pipe out of the mild or low-alloy backing steel. The stainless or other alloy liner panels usually are shaped and preformed to fit the shape and contours of the prefabricated vessel or pipe section. They are subsequently attached by welding to the backing steel. Where the contours of a vessel or a straight pipe section of relatively large diameter have a gradual curvature, flat liner panels may also be brought into tight contact with the backing steel by means of pressing and tacking procedures.

The most widely used lining methods on pressure vessels and tanks are plug welding, strip welding and through welding. Pipe lining is generally limited to strip welding methods.

Plug Welding

In plug welding, the lining is attached by welding each liner panel to the backing steel through holes punched or drilled through the liner panel material, Fig. 2. Ordinarily in vessel fabrication the size of the liner panel varies from 2 to 3 ft wide to 5 to 10 ft long. Holes are 1½ to 1 in. diameter. Smaller than ½-in. hole diameters can cause welding difficulties by shorting out the welding arc, resulting in excessive porosity or slag entrapment and in poor bonding. Where the liner panel thickness exceeds ⅛ in., the edges of the holes are occasionally beveled, as illustrated in Fig. 3.

Center to center distance between the holes should depend primarily upon the service conditions. The distance should be decreased for applications involving thermal cycling or temperature gradients. The values in Table 1 are generally used by design engineers as a guide.

FIG. 5. Strip welding of vessel (Courtesy C. F. Braun & Co.).

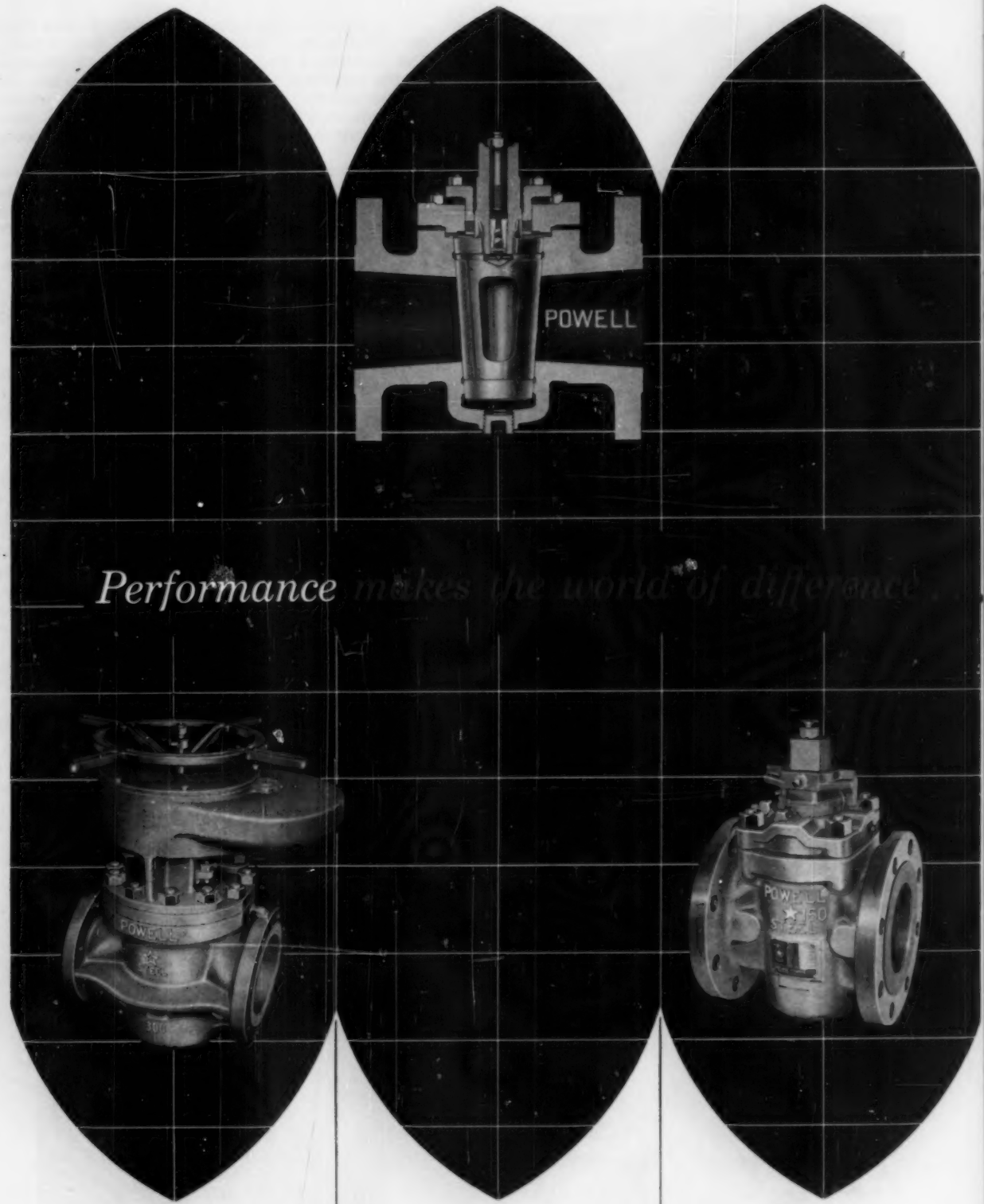

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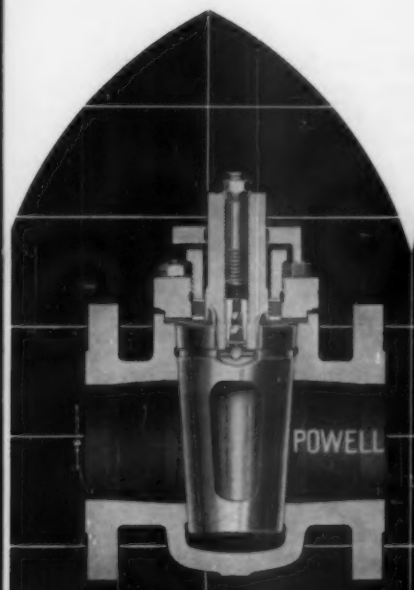
Fig. 1559—Flanged end carbon steel Lubricated Plug Valve. ASA 150 pound. Also furnished with screwed ends—Fig. 1558.



POWELL LUBRICATED PLUG VALVES

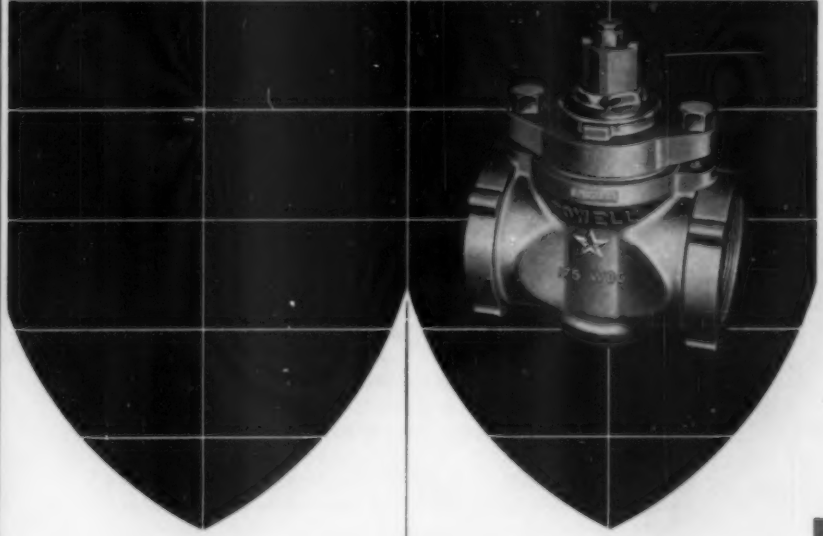


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TABLE 1. Hole Center Distances for Plug Welded Liners.

Maximum Operating Temperature (F)	*Center-to-Center Distance Between Holes (in.)*
up to 450	4 - 6
450-750	4
750-850	3½
850-950	3
over 950	2½

In vessels operating under a vacuum a center to center distance of 3 to 4 in. is frequently recommended. For room temperature service not involving thermal or mechanical fatigue, center to center spacings of as much as 12 in. have been found acceptable.

Shielded metal arc welding techniques are normally used; however, the semi-automatic submerged-arc and inert-gas consumable metal-arc processes have also been successfully used. The former is restricted primarily to flat and horizontal welding. The latter is suitable for all position welding.

After the panel sections have been placed in positions and pressed against the backing steel at their centers, a tack weld is made through one of the center holes by depositing a weld bead across the bottom of the hole. Additional tack welds are subsequently deposited every third to fifth hole by gradually progressing outward from the initial center tack weld. The edges of the liner panel are tack welded to the backing steel with approximately 1-in. long seam welds about 5 to 10 in. apart.

The final plug welding is usually done by following a so-called "ring" welding procedure, Fig. 4, consisting of depositing a seal weld around the inner edge of the hole for fastening the liner, followed by "filling in" the center space.

Strip Welding

In strip welding the liner is attached to the backing steel by means of welds attaching adjacent sheets to each other and to the backing steel, Fig. 5.

Length of the strips usually varies from 2 to 3 ft for field applied liners and from 2 to 10 ft for shop applied liners. Width of the strips may vary between 2 and 6 in. depending upon the service requirements. The values given in Table 2 are generally followed as a guide by design engineers.

TABLE 2. Strip Widths for Strip-Welded Liners.

Maximum Operating Temperature (F)	*Maximum Strip Widths of Stainless Steels*	
	Type 400 Series (in.)	*Type 300 Series (in.)*
up to 450	up to 6	up to 6
450 - 750	4½ - 5	3 - 4
750 - 850	4	2½ - 3
850 - 950	3½	2
over 950	3	2

Narrower strips should be used when the service involves severe thermal cycling or steep temperature gradients. On the other hand, strips or widths as much as 24 in. have been used for essentially non-critical service applications at room temperature.

In cylindrical vessels the strips are usually applied perpendicular to the longitudinal axis of the vessel. On conical

FIG. 7. 4-in. wide liner plates on 14-in. OD pipe strip line by shingle method.

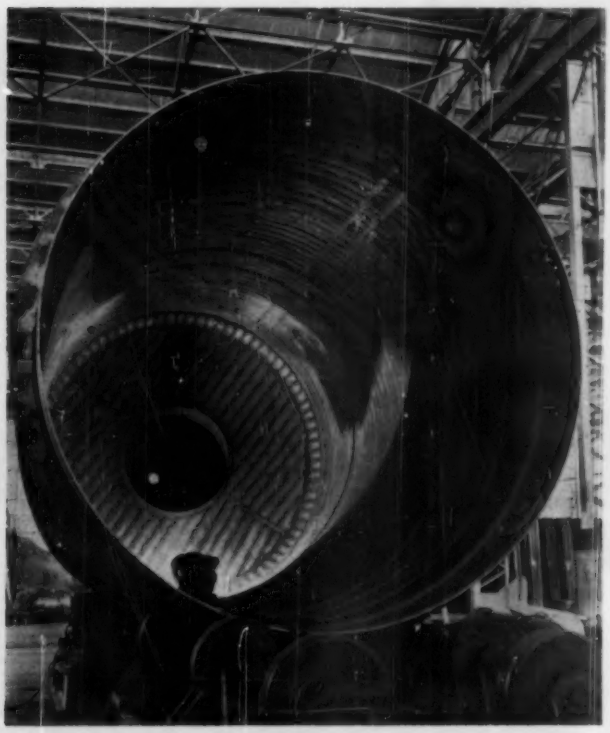


FIG. 6. Strip lined vessel with liner panels arranged in parallel in dished head sections on vessel (Courtesy C. F. Braun & Co.).

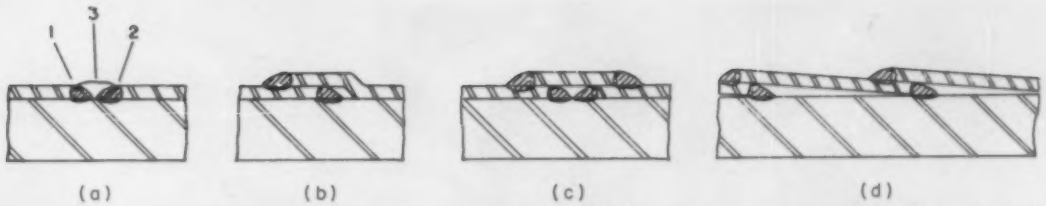


FIG. 8. Principal strip lining methods: (a) fillet butt; (b) cap or joggle; (c) butt strip and (d) shingle.

and dished shapes, parallel arrangements are preferred, Fig. 6. Dished heads are lined either with parallel or herringbone arrangements, the latter being frequently preferred since it reduces the tendency for welders to lap or shingle the strips.

On pipe the width of the liner strips depends on the diameter; in other words, the inside curvature. For example, on 14-in. pipe 4-in. wide liner strips would generally be considered practical, Fig. 7.

Typical strip lining methods are illustrated in Fig. 8. The "three-bead" fillet butt-welding procedure, Fig. 8a is generally preferred. Possible undesirable effects which may be the result of weld metal dilusion* usually are prevented by the use of a higher alloyed electrode. For example, on 18 Cr-8 Ni stainless steel liner plates a 25 Cr-20 Ni stainless steel electrode would normally be recommended.

Three "lapping" methods are occasionally used, particularly where undesirable weld metal dilusion cannot be avoided by means of electrodes more highly alloyed than the liner alloy. Fit-up also is not as much a problem with these lapping methods. However, the lapping methods are more costly than the fillet butt welding procedure shown in Fig. 8a. For example, in the butt strip method, Fig. 8c, four weld deposits are required for each joint. The lap welds on liner panels with formed edges in Fig. 8b require a special forming operation. The lapping methods also require a larger quantity of alloy liner material. Other objections are that the ridge effect in "lapped" linings makes cleaning more difficult; that welds covered by lapped linings cannot be inspected; and that lapped linings will not withstand as high a hydrostatic force tending to pull them loose from the base plate as plug welded or fillet butt welded liners. Nevertheless, lapping is frequently preferred by design engineers. On pipe and fitting shapes lapping techniques are almost exclusively used. In Fig. 9 is illustrated the shingle technique recommended for 10 to 20-in. diameter pipe, employing 4 to 5-in. wide liner strips. Where liquids flow thru the lined piping system the ends of the shingles overlapping previously welded shingles should be on the downstream side.

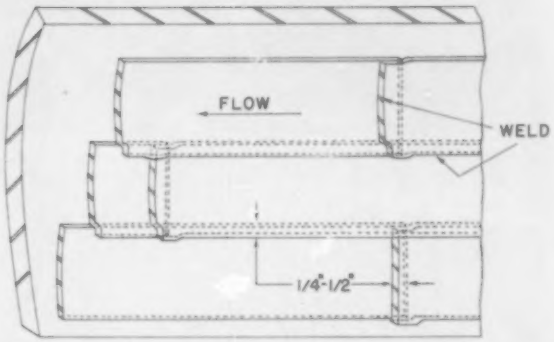


FIG. 9. Shingle strip lining method recommended for piping.

Through Welding

In through welding the liner panel is attached by depositing a submerged-arc weld along the edge of each panel and also a series of submerged-arc welds through the liner panels by fusing "through" the liner and penetrating into the base steel. Panels 1½ to 2 ft wide by 3 to 2 ft long represent typical sizes employed on pressure vessel and tank applications.

Prior to submerged-arc welding these preformed panels have to be carefully held in place with suitable jacks and tack welds. Some fabricators perform this tacking by manual submerged-arc welding plug welds at a center to center distance of about 8 in., Fig. 10.

The subsequently made "through" welds are usually spaced 3 to 5 in. apart. Good bonding is obtained with a penetration of about 1/16 in., which represents common practice. Because of dilusion by the backing steel, it is desirable to use more alloyed electrodes, as mentioned earlier.

Design Aspects

When vessels or piping are to be lined in the shop or in the field detailed drawings should be carefully made of the liner panels which are to be fabricated and fitted into the existing structure. In case of newly fabricated vessels the detailed drawings for the liner panels may be made from drawings of the existing shell. However, when old vessels which have been in service are to be lined, it is usually advisable to base the detailed drawings upon actual measurements, since the service conditions may have changed some of the original dimensions.

Attention should be given also to the size of the liner panels required in vessels, pipes, fittings, end caps, etc., the size and spacing of the holes (when plug welding is used) and panel details around openings, baffles, traps, couplings, nozzles, etc. Recommendations for normal design details for several of these are illustrated in Fig. 11.

Generally the liner panels are first cut out and shaped. However, where old vessels are involved which are somewhat irregular in shape and can be lined in a shop, it may at times be more convenient to delay cutting and shaping until the actual assembly and welding time.

Preforming of the liner panels is advisable where the surface contours to be lined are irregularly shaped. However, where the contour is uniform and curved as in large diameter tanks, it frequently may not be necessary to preform (roll) the liner panels. Instead they may be pressed uniformly and tightly against the inner surface of the vessel by jacking arrangements.

Prior to lining the fabricated vessel must be thoroughly cleaned, preferably by sand or shot blasting.

Each preformed and preshaped liner panel must be care-

*Dilusion describes the mixing of the molten welding filler metal being deposited with that portion of the base metal which is melted (fused) by the welding operation.

FIG. 10. Plug "tack" welding stainless-steel sheets by submerged-arc welding prior to through-welding (Courtesy C. F. Braun & Co.).

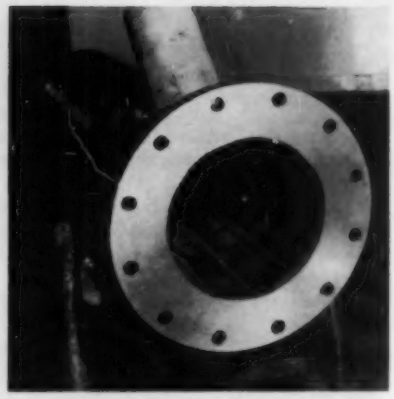


FIG. 12. Machined flange face of pipe section after strip lining with Hastelloy and seal welding end of liner panels to flange.

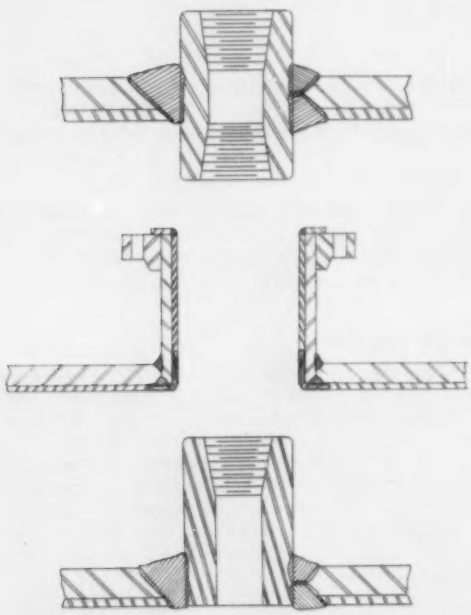


FIG. 11. Examples of nozzle and coupling details on vessels of applied liner construction.

fully laid out, held tight against the backing steel and tack welded. For holding the panels against the backing steel hydraulic jacking or "spider" arrangements are generally used.

Weld-Metal Overlace

At locations in lined vessels, pipe or fittings where, because of inaccessibility it would not be practical to apply liner plates, it may frequently be more convenient to apply weld metal overlays. The same applies to the ends of flanges where the gap between the liner strips and flange face plate must be "overlayed" or filled with weld metal, Fig. 12. Thus, at pipe inlets, manhole openings, etc., the exposed backing steel surfaces can be protected by weld metal overlays with welding rod alloys of proper composition. Naturally, the effects of dilusion must be considered in the selection of the proper filler metal.

Electrode and Welding Rod Selection

In Table 3 are listed the electrode and welding rod compositions ordinarily recommended for welding the more commonly used lining materials to mild or low alloy backing steels. * * *

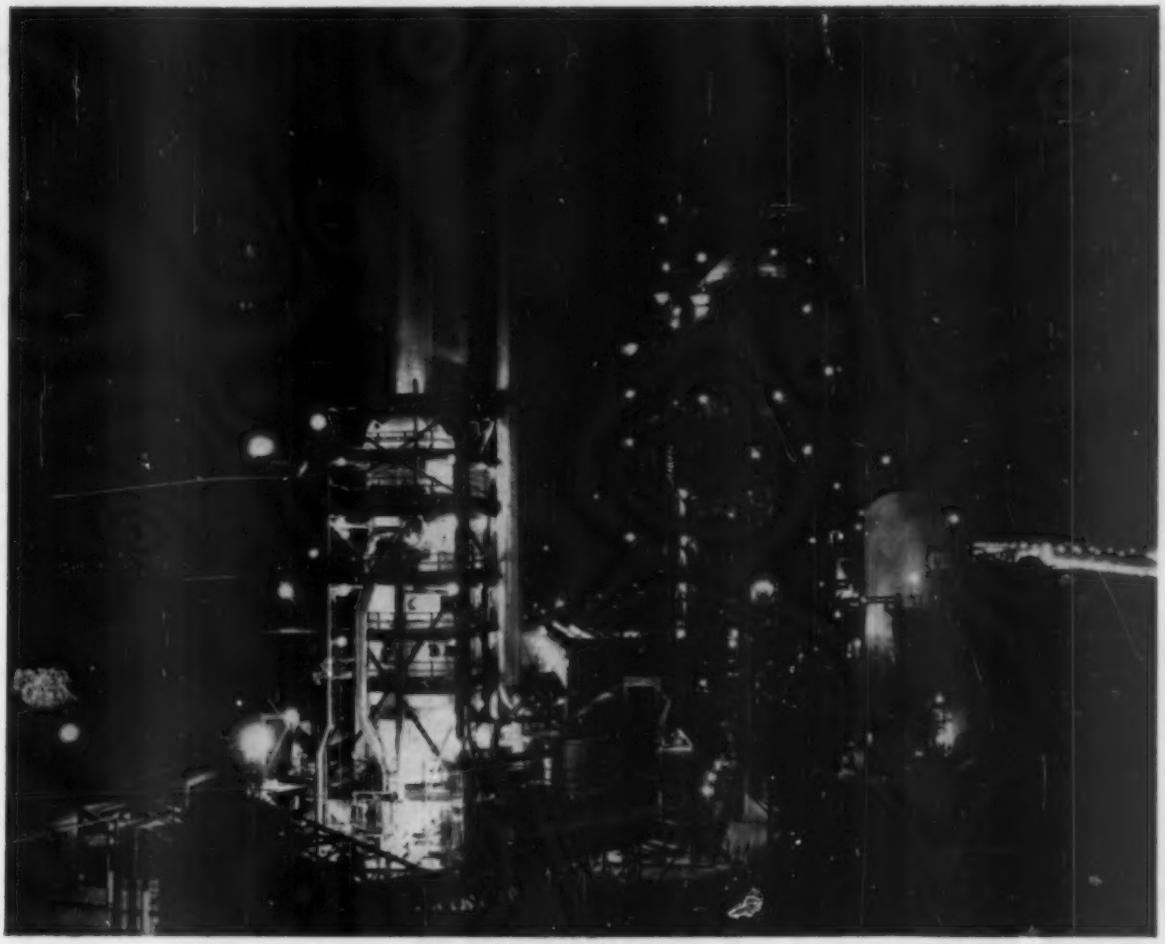
TABLE 3. Electrode and Welding-Rod Compositions for Welding Liner Panels to Backing Steels.

Liner Material	Weld-Metal Dilution Is Involved ‡ First Pass and "Through" Welding	Weld-Metal Dilution Is Not Involved ‡
302	E310, E309	E310, E309, E308
304	E310, E309	E310, E309, E308
304L*	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347, E308L*
309	E310	E310, E309
310	E310	E310
316	E310 Mo, E309 Mo	E310 Mo, E309 Mo, E316
316L*	E310 Mo	E316L*, E318
317	E310 Mo	E317
321	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347
347	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347
405	E310, E309, E430†	E310, E309, E430†
410	E310, E309, E430†	E310, E309, E430†
430	E310, E309, E430†	E310, E309, E430†
Nickel	Nickel(No. 141)	Nickel (No. 141)
L-nickel	Nickel(No. 141)	Nickel (No. 141)
Monel	Monel(No. 140)	Monel (No. 140)

*The letter L, as recently adopted by the American Iron & Steel Institute, denotes the extra-low-carbon (0.30% max C) grades.

†Must be used under certain corrosive conditions and may require special preheat and postheat treatments.

‡The prefix E signifies covered electrodes specified by AWS 5.4-55T and ASTM A298-55T. Where bare electrodes or welding rods are used the prefix ER applies as specified by AWS 5.9-53T and ASTM A371-53T.



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The unit can generate 138,000 lb of steam per hour at 300 psig and 540 F. The boiler can operate on oil plus combustibles in the cat cracker regenerator flue gas, or on oil alone.

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CO Boilers are setting similar performance and economy records in refineries throughout the world. The B&W CO Boiler is the only unit specifically designed for efficient burning of "waste" carbon monoxide. Check your own steam costs—then check with us and learn how a CO Boiler can cut those costs. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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CO-107

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Continue to study your chosen field or specialty. Your learning process must never cease functioning.

Seek additional training, technically or in non-technical fields which can be of importance to future development.

Think creatively about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

Expand your capacity to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

Take a genuine interest in people, their potentials, their problems. Understand, but don't condemn, their shortcomings.

Broaden your base of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

Study the fundamentals of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and limitations.

Seek advice and counsel from others; don't rely entirely on your own resources . . . Ask questions.

Participate actively in technical societies; keep alert to professional trends, changing concepts, new developments.

Use common sense and sound, practical judgment in evaluating everything from people to processes.

Aggressively pursue your professional and personal ambitions, but with patience and intelligence.

Learn to communicate your ideas and opinions pleasantly, clearly, concisely, aggressively to your superiors, associates, subordinates.

The development of a successful career in engineering bespeaks **constant, consistent dedication** to professional and personal principles. Perhaps these few paragraphs can serve as a guide for your own engineering future and advancement. (Footnote: for more detailed discussion of the suggestions made herein, write for your free copy of "14 Ground Rules," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd like to demonstrate how these "14 ground rules" affect our heat exchangers!

PETRO/CHEM new equipment

Pour points of heating oils depressed by new additives

Paradyne HO-10 and HO-20, designed to depress the pour points of heating oils, offer flexibility in utilizing available oil stocks and equipment to refiners and marketers of heating oils that are destined for cold weather service. *Enjay Chemical Company.*

Circle number (40) on reply card.

Integrating recorder suited to gas chromatography use

New strip-chart integrating recorder is particularly oriented toward gas chromatography applications. Five different maximum count rates are readily obtained through an adjustable gear system up to a maximum of 40,000 area counts per minute. The counting rate linearity is ±0.5% of full scale. The integrator channel, installed as a second channel in a standard wide-grid, single channel "servo/riter" potentiometric recorder, consists of a special potentiometer-amplifier-servo arrangement and activates an "area trace" automatically and simultaneously with the signal trace. *Texas Instruments Incorporated.*

Circle number (41) on reply card.

New gas purification process increases capacity, cuts cost

New Catacarb process is said to result in substantial increase in gas treating capacity of plant, improved gas purity, reduced unit utility costs, and elimination of troublesome sludge. Process is applicable to the purification of hydrogen, natural gas, and refinery gases in connection with production of ammonia, urea, sulfur from sour gas; hydrogen treating; hydrocracking; Btu improvement of natural gas; production of ethylene oxide, methanol, dry ice; oxo-synthesis, and processes for the direct reduction of iron ore. *A. G. Eickmeyer.*

Circle number (42) on reply card.

Cut on shorter pipe segments with new beveling machine

New line of pipe beveling machines features only improvement in design made on this type unit in 25 years. Shorter, balanced ring gear-saddle assembly makes it possible to cut on shorter segments of pipe. Storage space is reduced by approximately one-half. Light weight makes machine easier to handle. *C. A. Mathey Machine Works, Inc.*

Circle number (43) on reply card.

Hydrogen treating catalyst

Aero HDS-3, now commercially available, is a new hydrogen treating catalyst developed in conjunction with Shell Development Company. A desulfurization catalyst, it shows markedly increased nitrogen and polyaromatics removal over cobalt-molybdenum catalyst compositions. *American Cyanamid Company.*

Circle number (44) on reply card.

'Midget' takes moisture from air for pneumatic controls

The "Frigid Midget" moisture condenser removes moisture from compressed air supplied to pneumatic control systems before it can enter the control system piping. Condensed moisture is discharged through an automatic trap. Here's how it works:

Ice is formed around refrigerant coils in a hermetically sealed heat exchanger. Compressed air passes through coils which are adjacent to the ice. The compressed air is cooled and the moisture in the air is condensed. The condensed moisture is separated in a specially designed chamber and is removed through the trap.

Unit can dry 10 cu ft of air per min and produce a dew point of —8 F or lower when air enters the condenser at pressure of 50 psi and saturated with moisture at 98 F. *Royse Manufacturing Co.*

Circle number (45) on reply card.

Accessories protect gages from pulsation, corrosion

Pulsation dampener and a chemical attachment offer improved performance and easier maintenance where gages must be protected from damaging effects of pulsating pressures or corrosive chemicals. Both accessories have a diaphragm (stainless steel or Neoprene) which separates the measured fluid from the gage measuring element. Space above the diaphragm is filled with a viscous non-freezing liquid which transmits the measured pressure to the gage element. *U. S. Gage Division, American Machine & Metals, Inc.*

Circle number (46) on reply card.

Catalyst for dealkylation

C30 catalyst, for dealkylation in general, and more specifically for the conversion of toluene to benzene, is a chromia-alumina catalyst on a special grade of alumina. *Catalysts and Chemicals Inc.*

Circle number (47) on reply card.

Advantages offered by new centrifugal air compressor

Integral gear design of new 4-stage integral gear centrifugal compressor allows direct coupling to a low speed motor driver, thus eliminating a high speed coupling and resulting in fewer installation problems. Unit is virtually vibration free because of its stiff shaft design which operates below the critical speed. Available in air-inlet capacities ranging from 4000 to 30,000 cu ft per min and discharge pressures of 60 to 105 psig. *Worthington Corporation.*

Circle number (48) on reply card.

Automatic gas desulfurizing unit for capacity from 500 Mcf

Sweet-A-Mine automatic gas desulfurizing unit removes hydrogen sulfide and carbon dioxide from gas by absorbing the acid gases in a solution of monoethanolamine in water. The resulting sour amine solution is regenerated for reuse. Can operate unattended, requiring only supply gas to actuate pneumatic valves and fuel gas for the reboiler. Will operate efficiently under all climatic conditions. Available for any gas capacity, starting with 500 Mcf per day. *Maloney-Crawford Tank & Manufacturing Co.*

Circle number (49) on reply card.

Bi-metallic pipe is strong, highly corrosive resistant

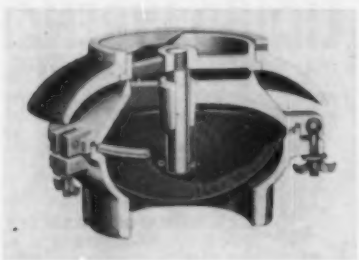
Bi-metallic pipe provides all the fabrication and strength advantages of a carbon steel system, combined with the corrosion resistance of the best alloy materials, and at a fraction of the cost of solid alloy piping. In the manufacture a seamless lining is hydraulically expanded into the base pipe, forming the lining tightly against the inside of the base pipe material. Additional pressure expands the base pipe, and on return to normal operating pressure, the lining is firmly held against the base pipe due to differential contraction. With this system, the choice of materials for bi-metallic pipe is virtually unlimited. *Gray Tool Company.*

Circle number (50) on reply card.

New optional features extend capabilities of 1620 computer

Installation of new optional features will give the 1620 data processing system a tripled memory capacity plus punched card input and output. Both features can be added to the original computer in a customer's office in one day. With the new features the computer is equipped to handle payroll, inventory control, quality control, and production forecasting, and can also be used in support of larger data processing systems. *International Business Machines Corporation.*

Circle number (51) on reply card.



Computer performs 3 basic process control functions

A new analog computer that performs any one of the three mathematical functions most common to process control has been introduced for use with Autronic instrumentation systems. The C4A/2 can extract the square root of a single input or ratio or multiply two inputs from any Autronic primary transmitter. Its output signal is the accurate analog value for the given mathematical function, and can be used to directly operate any Autronic recorder, indicator, or controller. *Swartwout Division, Crane Co.*

Circle number (52) on reply card.

Vacuum indicator-controller offers outstanding accuracy

New thermocouple-vacuum-gage indicator-controller is especially adaptable to close-tolerance control systems. Through use of a vane-and-coil type control mechanism, the instrument offers closer, more reliable control and more accurate indication for such vacuum system applications as distillation than is possible with contact-type models. Instrument can initiate control on either increases or decreases in pressure. Control point is adjustable over the entire calibration range, which is one to 1000 microns. *General Electric Company.*

Circle number (53) on reply card.

Top-entry ball valves made with socket weld connections

McCannaseal top-entry ball valves are now available with socket weld connections in 1, 1½, 2, and 3-in. sizes. New design permits valve body to be permanently welded into the line. Access to valve parts is provided by removable bonnet and stem assembly. Socket dimensions are made to American Standard Steel Socket-Weld Fittings Schedule 40. Body materials are carbon steel or stainless steel, type 316. Seats are Teflon or Buna-N. Valves are designed for controlling gases, liquids, slurries, semisolids, difficult-to-handle and corrosive chemicals at temperatures from −100 to maximum 350 F. *Hills-McCanna Company.*

Circle number (54) on reply card.

2-pen round-chart recorder accurate to within ±0.25%

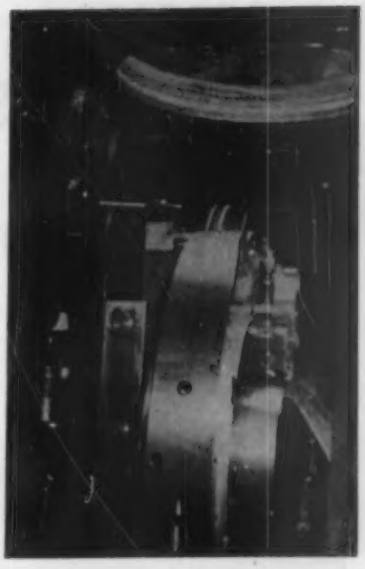
New 2-pen potentiometric round-chart recorder-controller, accurate to within ± 0.25%, can be used in nearly any industrial application where two variables must be recorded on a single chart. The recorder's two measurement circuits may be either potentiometric or bridge-type, or a combination of both. *General Electric Company.*

Circle number (55) on reply card.

New emergency vents provide protection for storage tanks

New 209-U emergency vents have large diameter plate in cap which is sealed with fusible metal. If fire occurs, the fusible metal melts at 200 F, and the plate blows off to give full upward venting. Vent is set to relieve at 10 oz pressure. Should be used with a vacuum relief vent. *OPW Corporation.*

Circle number (56) on reply card.



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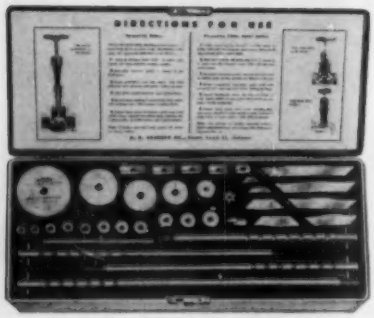

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Circle number (57) on reply card.

Coupling for quick-connect permanent pipe installations

Rigid-Line series of quick connect, quick disconnect coupling is designed solely for permanent piping applications. No flexible hose is required on either end of coupling, which seals tight on the user's choice of rubber gasket. Used in pairs, the coupling is ideal for quick addition or removal of valves, gauges, pumps, or meters in permanent pneumatic, hydraulic, or other fluid flow lines. Available in ½ and 1-in. ID sizes with choice of three metals: cadmium plated steel, anodized aluminum, or Type 316 stainless steel, passivated. *Snap-Tite, Inc.*

Circle number (58) on reply card.

New lead compound provides better antiknock performance

New antiknock compound Tetramix combines tetraethyl lead, tetramethyl lead, and mixed methyl ethyl lead compounds . . . provides improved antiknock performance in many gasoline blends. Tests show that in many cases desired road octane levels can be achieved more economically with Tetramix than with other lead compounds. *Du Pont Petroleum Chemicals Division.*

Circle number (59) on reply card.

Multistage liquid extractor for pilot plant operation

Multistage mixer-settler liquid extractor is applicable for pilot plant solution of complex extraction problems and for limited-scale production. Permits experimental determination of both the equilibrium and operating lines for any type of liquid extraction process and permits a complete analysis of the operation. Developed by Pennsylvania State University and Esso Research and Engineering Company. *The Pennsylvania Tool & Mfg. Co.*

Circle number (60) on reply card.

Unique new valve controls flow with squeeze action

Squeeze action in new Tube-O-Matic valve automatically controls flow of air, oil, chemicals, and even grinding slurries without use of poppets or spools. There are no metal-to-metal contacts and no metal-to-rubber seals. Can handle pressures up to 200 psi. Available for pipe sizes from ¼ to 12-in. *Airmatic Valve, Inc.*

Circle number (61) on reply card.

10-in. turbo-meter measures wide range of oil products

New 10-in. turbo-meter measures oil products under widely varying flow rate and viscosity conditions. With accuracy of ±0.15%, instrument indicates amount of crude or refined products passing through a 10-in. line at rates as high as 7000 bbl per hr. Has repeatability of better than one part in 500. *Rockwell Manufacturing Co.*

Circle number (62) on reply card.

Snap-O-Trol pressure switches for either type control system

New diaphragm-operated adjustable pressure switches are available in two models. Model CADM is equipped with a 3-way snap action micro valve for pneumatic control systems, while Model CADMEX is equipped with an explosion-proof, UL and CSA-approved micro switch for electric control. *Instruments, Inc.*

Circle number (63) on reply card.

No-clog ink supply system is standard equipment on meters

A capillary-type, non-clogging ink supply system featuring clear plastic ink cartridges that show the ink supply at all times is now standard equipment on all new Ring Balance meters. Disposable cartridges contain a three to four month ink supply . . . slip into place in a matter of seconds. Replacement units are available to apply the system to meters already installed. *Hagan Chemicals & Controls, Inc.*

Circle number (64) on reply card.

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Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion and joint seizure.

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PETRO/CHEM new literature

Accessories for DK spectrophotometers . . . which adapt them to the requirements of such analyses as flame photometry, fluorometry, reflectometry, spectroradiometry, colorimetry, solid phase studies, reaction rate studies, and turbidity observations . . . are detailed in Bulletin 738. *Beckman Instruments, Inc.*
Circle number (65) on reply card.

Capacitance level controls . . . are subject of new bulletin that gives mechanical and electrical data plus descriptions and drawings of typical applications. *Weighing & Controls, Inc.*
Circle number (66) on reply card.

Composition under gas chromatography . . . of 30 neo-fat fatty acids . . . is detailed in new catalog. *Armour Industrial Chemical Co.*
Circle number (67) on reply card.

Crane/excavator . . . Air-controlled 900 series crawler crane/excavator is subject of Catalog 790-CG-1. *American Hoist & Derrick Company.*
Circle number (68) on reply card.

Cylinder Conomotor actuators . . . Series 50 . . . for automatic throttling control of valves, proportioning pumps, variable speed drives, flow regulators, rheostats, autotransformers, etc., . . . are described in Data Sheet 102. *Conoflow Corporation.*
Circle number (69) on reply card.

Deterioration of wood in cooling towers . . . causes, symptoms, and suggested cures . . . is explained in Reprint 85. *Nalco Chemical Co.*
Circle number (70) on reply card.

Features of new motor control center . . . are given in 4-color bulletin GED-4152. *General Electric Co.*
Circle number (71) on reply card.

Fig. 6970 desuperheaters . . . which with adequate controls operate dependably at turn-down ratios as high as 50 to 1, in temperature ranges of 10 to 50 F above saturation temperature . . . are explained in Bulletin 6D. *Schutte and Koerting Company.*
Circle number (72) on reply card.

Gas chromatograph . . . with tape programming for greater precision and flexibility in process stream analysis . . . is featured in Bulletin 0714-5. *Mine Safety Appliances Co.*
Circle number (73) on reply card.

Grating and stair treads . . . are subject of Bulletin 1112, which gives design data, panel widths, and load tables for Tru-Weld grating and stair treads with both standard and close spacing. *Dravo Corporation.*
Circle number (74) on reply card.

Heat transfer equipment . . . is covered in new 32-page 3-color general catalog, No. 160. *Young Radiator Company.*
Circle number (75) on reply card.

Hinged closures . . . for blanking off pipe ends and tank or vessel openings . . . are subject of revised Bulletin TT956. *Tube Turns Division, Chemetron Corporation.*
Circle number (76) on reply card.

Hydro-Foil pumps . . . designed to permit effective control and regulation of huge volumes of water . . . are detailed in Bulletin B-148. *Peerless Pump, Hydrodynamics Division, Food Machinery and Chemical Corporation.*
Circle number (77) on reply card.

Instrumentation tubing . . . 12-page Bulletin 380 is probably the first literature prepared specifically to help designers in their selection of instrument tubing. *Superior Tube Company.*
Circle number (78) on reply card.

Liquid cyclone classifiers . . . Rubber-lined Type FR DorrClone, available in 6, 12, and 24-in. diameters, is explained in newly revised Bulletin 2503. *Dorr-Oliver Inc.*
Circle number (79) on reply card.

Multi-tube, double-pipe heat exchangers . . . Design features, applications are described in Bulletin 111. *Brown Fintube Company.*
Circle number (80) on reply card.

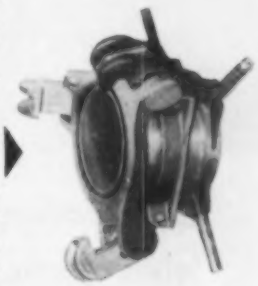
2 New Developments to Modernize Your Liquid Handling Operation

Flight Refueling engineers were asked to apply their extensive aerial refueling systems background to current needs of the commercial fluid handling industries. Here are the results!

"dripless dripstick"

Accurately measures the liquid contents of any container—fast and safely. Mounted top or bottom, this indicator remains hermetically sealed. Just read the extended calibrated rod as it "pops" out of the sealed container.

"QD-16 coupling"



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Operating characteristics of 10,000 hp LM compressors . . . are outlined in Brochure 99. Booklet also describes controls which can make the compressor into a completely automatic unit which starts itself, shuts itself down, or can operate fully unloaded. *The Cooper-Bessemer Corporation.*

Circle number (121) on reply card

Organic chlorine compounds . . . Their use as solvents, extractants, fumigants, intermediates, and special-purpose fluids is treated in new 44-page booklet. *Union Carbide Chemicals Company.*

Circle number (122) on reply card

Pipe protection . . . Advantages of using laminated butyl rubber and plastic tape in combination with a butyl base primer as a corrosion resistant pipe wrap are explained in illustrated brochure. *Plicoflex, Inc.*

Circle number (123) on reply card

Piping flexibility service . . . in which a high speed automatic digital computer is used in making accurate flexibility analyses of complex piping systems . . . is described in new booklet. *Service Bureau Corporation.*

Circle number (124) on reply card

Pneumatic computing relay . . . Sorteberg Force Bridge, for squaring, square root extraction, ratio setting, multiplication, and division in pneumatic circuits, is detailed in Catalog 53CR1000. *Fischer & Porter Company.*

Circle number (125) on reply card

Pneumatic pressure and temperature controllers . . . controlling pressures up to 10,000 psi and temperatures from minus 125 to plus 1000 F . . . are described in Catalog J-C. *OPW-Jordan Corporation.*

Circle number (126) on reply card

Positive displacement blowers . . . are described and illustrated in Bulletin S59-H, which deals with the company's California series. *Sutorbilt Corporation.*

Circle number (127) on reply card

Procedures for determination of contamination in hydrocarbons . . . are detailed in 12-page technical report. Two methods are described, both of which depend on filtration through a membrane filter and subsequent microscopic observation. *Gelman Instrument Co.*

Circle number (128) on reply card

Return line corrosion need not be a problem . . . according to new water conditioning data sheet which discusses how causes of corrosion can readily be identified and economically corrected. *Betz Laboratories.*

Circle number (129) on reply card

Sight Glasses . . . for use in ovens, absorption columns, reaction kettles, furnaces, stills, and processing tanks . . . are subject of Bulletin EB-20. Covers product specifications and graphically presents data on pressures and temperatures. *Corning Glass Works.*

Circle number (130) on reply card

Steel pipe and tubing for high temperature service . . . is subject of 6-page folder T-467. Has chart containing data on tensile properties, thermal conductivity and expansion, creep strength, oxidation resistance, and other mechanical and physical properties of importance to application engineers. *The Babcock & Wilcox Co.*

Circle number (131) on reply card

Tank cleaner . . . new heavy-duty Model "H" . . . is described in Bulletin 444. Photos show dimensions, working positions. *Sellers Injector Corp.*

Circle number (132) on reply card

Techniques for mounting tubing, wiring, and other hardware . . . are offered in 76-page illustrated engineering design manual, Bulletin 212-G. Lists materials, specifications, recommended application. *TA Mfg. Co.*

Circle number (133) on reply card

Use of Ranarex gravitometers for H_2 recycle gas in catalytic reforming . . . is explained in data sheet RD-101. *The Permutit Company.*

Circle number (134) on reply card

Welded steel tubing . . . available as fabricated or semi-fabricated items in five different steels . . . is subject of folder P. O. 6759. *Armco Steel Corporation.*

Circle number (135) on reply card

Wall chart of conversion factors . . . is handy reference table that gives many conversions difficult to locate in reference manuals as well as such common ones as inches to centimeters, watts to horsepower, cubic feet to liters, etc. *Precision Equipment Co.*

Circle number (136) on reply card

Specialized EFCO Experience

Solves Specific HEAT TRANSFER PROBLEMS . . .

Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job rating. Gulf Oil Corporation is one of many process equipment users who are benefiting from EFCO's specialized experience and engineering efficiency.

This Gulf Oil Corporation installation of Efco units, in Gulf's Port Arthur Refinery, is typical of the many high-pressure, high-temperature exchangers designed and fabricated by EFCO.

EFCO'S FOUR POINT PROGRAM PROVIDES:

• service-proved engineering design • guaranteed job-ratings • complete fabricating facilities • technical service before, during and after installation

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116

PETRO/CHEM newsmakers

▸ Retirement of three veteran Mobil Oil Company refinery managers January 1, 1961, will result in new managers being appointed at five plants.

L. E. Cranston, manager of the Paulsboro, New Jersey, refinery, will replace the retiring **P. L. Smith** at Beaumont, Texas.

R. C. Hartman, operating superintendent at Paulsboro, will succeed **W. W. Reed** as manager of the East Chicago, Indiana, refinery. Hartman's successor will be **R. E. Maescher,** now operating superintendent at Torrance, California.

W. B. Kleihege, assistant manager at East Chicago, will succeed **E. T. Pummill,** retiring manager of the Casper, Wyoming, plant.

S. W. Thomson, now assistant manager, will become manager of the Paulsboro installation. The new assistant manager will be **B. L. Rodzianko,** now in charge at the East Providence, Rhode Island, plant.

A. H. Fuller, now engineering and maintenance superintendent, will become manager of the East Providence refinery.

▸ Houdry Process Corporation, Philadelphia, announces appointment of **David B. Ardern** as an executive director of Katalysatorenwerke Houdry-Huels, GmbH, new catalyst company in Marl, West Germany, jointly owned by Houdry and Chemische Werke Huels, Marl.

Willis J. Cross will succeed Ardern as director of technical service, while **Donald E. Womeldorph** will replace Cross as assistant director.

▸ Refining division appointments, California Oil Company:

John J. Cullen, general superintendent, Perth Amboy, New Jersey, refinery.

John E. Walkey, manager, engineering and technical services.

Minor L. Fahrmann, manager, maintenance and construction.

W. C. Nielsen, assistant manager, engineering and technical services, and chief engineer.

G. H. Jefferis, superintendent, manufacturing and utilities.

▸ **Thomas G. Reynolds** has joined Sun-Olin Chemical Company as project manager for the $20,000,000 ethylene and ethylene oxide plants under construction adjacent to Sun Oil's Marcus Hook, Pennsylvania, refinery.

H. Harold Bulkowski and **Manlio M. Mattin,** process engineers, and **Samuel L. Palese,** civil engineer, all of whom are new with SunOlin, are engaged in engineering plans for the expansion program.

▸ New vice president and general manager of Cit-Con Oil Corporation, Lake Charles, Louisiana, is **Edward W. Midlam,** who was staff executive, manufacturing department, Cities Service Petroleum, Inc. Midlam has also been elected a director of Cit-Con.

▸ Appointments at Humble Oil & Refining Company's Baytown, Texas, refinery:

W. A. McElhannon, senior supervising engineer, technical department, cracking and light ends division.

W. T. Jones, senior chemical engineer, process technical division.

E. A. Clarke Jr., staff engineer, applied mathematics and computing section, technical division.

▸ Recent appointments at Standard Oil Company (Indiana) Whiting research laboratories:

Dr. Vernon P. Dorweiler, technical-computing supervisor.

John F. Holohan Jr., who will carry out pilot plant studies of new processes for making chemicals from petroleum products.

D'Arcy C. Randall, who will work in the field of new applications for electronic computers.

▸ California Research Corporation promotions:

E. H. Lynch, now supervising research engineer, refinery technical service, Richmond laboratory.

S. G. Miller, named to succeed Lynch as group supervisor, refinery technical service, El Segundo laboratory.

▸ **R. J. McPeak** has joined The M. W. Kellogg Company Research and Development Laboratories, Jersey City, New Jersey, as a mechanical engineer. Before going with Kellogg he was an instructor at Iowa State University, Ames.

The readers always write...

J. C. Martin is to be complimented for his "How to Measure Project Profitability" (Aug. '60), particularly for showing that the percent return by Investor's Method is comparable with percent return on total capital as determined from income statement and balance sheets.

Case 3 in Table 10 was included for comparison with Case 1 to show effect of accelerated depreciation rate. Neither payout period nor rate of return by Investor's Method shows any effect from accelerated depreciation rate. This is contrary to the real situation in which federal income tax must be paid. Including taxes and working capital in the evaluation, values are:

Table 10. Project A.

Case	*Bases*	*Payout Period*		*Investor's Method*	
		(Cash Flow)	*Years*	*(Discounted Cash Flow)*	*% Return*
1	1-yr construction time, profit uniform	5	(3.3)	12.0	(24.2)
3	1-yr construction time, accelerated depreciation	4	(3.3)	13.6	(24.2)
4	1-yr construction time, accelerated profit	4	(2.5)	13.6	(29.6)

Values in parentheses are from the original Table 10.

Accelerated depreciation rate, Case 3, is now shown to increase rate of return and decrease payout period over the straight line depreciation rate used in Case 1. Evaluation of Case 3 now becomes consistent with that of Case 4, both of which have high initial cash flows, since both now show greater return than Case 1 where cash flow was uniform over the project's life.

Examples indicate importance of incorporating all pertinent information in the economic evaluation, including taxes.

LELAND W. CUMMINGS, *Sun Oil Company*

▸ Including income tax and working capital in developing the real situation is quite right. Objective, though, at that stage in discussion was to reveal basic difference in the various evaluation methods, and it was felt that this could best be illustrated by omitting the effect of taxes and other factors.

JOHN C. MARTIN, *The Atlantic Refining Company*

FLUID & GAS PRESSURE TANKS
STAINLESS & CARBON STEEL TANKS
(GOVERNMENT SURPLUS BARGAINS)

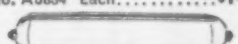
Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.

J-1 PRESSURE TANK Stainless steel, surplus aircraft oxygen tank, 48" long, 24" dia. Rated for 400 P.S.I. working pressure, 18,000 cu. in. vol., 77.9 gal. capacity. ¼" pipe thread fitting at each end. New condition. Shipping weight 247 lbs. F.O.B. Chicago.
No. AJ832.....$99.50

G-1 TANK Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AJ63 Each.....$14.95

NON-SHATTERABLE CO_2 CYLINDER This type of pressure bottle was used by the Armed Forces for inflating life rafts. 18¼" long, 3¾" dia. Has ½" pipe thread opening at one end. Capacity 2.98 lbs. of CO_2—at 1800 P.S.I. Shipping weight 10 lbs. F.O.B. Chicago.
No. AJ303.....$2.50

FREON TANK Capacity 22 oz. of Freon F22, 6 cc Methyl Alcohol. 18¼" long, 2" dia. ⅜" pipe thread opening at one end. Equipped with brass valve. Shipping weight 3 lbs. F.O.B. Chicago. (Six for $8.00).
No. AJ834 Each.....$1.50



D-2 AIR TANK Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
No. AJ391 Each.....$4.95

CORNELIUS HIGH PRESSURE (1500-2000 P.S.I.) AIR COMPRESSOR Three cylinder, 3-stage compressor, complete with 27 volt, D.C. 20 amp. motor, with fan. Rated 1500 P.S.I. continuous duty, 2000 P.S.I. intermittent. Pressure switch in base. As released by Air Force, in used, serviceable condition. Covered by our 30 day GUARANTEE. 11½" long, 7" high, 9" wide. Shipping weight 12 lbs. F.O.B. Chicago. Limited quantity.
No. AJ549.....$35.00

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DURA PLASTIC *Teflon* PACKING *created definitely for chemicals*

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A completely lubricated TEFLON PACKING

Provides long-term, dependable sealing of corrosive fluids. For service on all liquids except molten alkali metals and some fluorine compounds in the higher temperatures. Particularly suitable for sealing rods, shafts and stems on processing equipment handling hot caustics, acids, alkalies or organic solvents from -90°F. to 450°F.

FOR FURTHER INFORMATION WRITE FOR BULLETIN NO. 461

DURAMETALLIC CORP., Kalamazoo, Michigan

Processing Parade

Effective January 1, 1961, **De Laval Steam Turbine Company** will have two independent operating divisions.

The new machinery division will design and manufacture steam turbines, compressors, centrifugal pumps, and other large products usually made to individual customer specifications, while the power auxiliaries division will initially include foundry products and IMO pumps, and will act as a subcontractor to the machinery division for certain components.

Each division will have its own headquarters sales, engineering, and service staffs, and its own manufacturing facilities.

Production is underway at the new $4,000,000 **M. W. Kellogg** power piping manufacturing plant and division headquarters at Williamsport, Pennsylvania. John M. McAneny is general manager of the division.

Dresser Industries, Inc., Dallas, has purchased **Podbielniak, Inc.,** Chicago, manufacturer of centrifugal solvent extractors, laboratory fractional distillation apparatus, and packaged distillation plants.

TRW Computers Company is new name for **The Thompson-Ramo-Wooldridge Products Company,** computer division of **Thompson Ramo Wooldridge Inc.,** with headquarters in Beverly Hills, California.

Appointments:

Republic Flow Meters Company, Albert J. Rosenberger, manager, valve sales and engineering department; William R. Robinson, valve sales supervisor.

Rockwell Manufacturing Company, Harry W. Fisher, manager, central liquid meter products engineering; William W. Shade, district manager, meter and valve division, Kansas City area.

Perry Equipment Corp., C. R. Searcy, general sales manager, with headquarters at Mineral Wells, Texas.

Ingersoll-Rand Company, R. J. Bunch, manager centrifugal pump division; G. T. Jones, manager, condenser department; T. E. Bennett, manager, engineering pump department.

M. H. Detrick Company, T. J. Pohl, sales manager, insulation division, Chicago.

Fluor Products Company, Robert W. Kerr, president, and also vice president and a director of The Fluor Corporation, Ltd.

Wolverine Tube, D. M. Irwin, assistant general sales manager. Wolverine Tube, division of Calumet & Hecla of Canada, Ltd.; R. C. Cash, sales manager, Chicago district; John P. Howland, sales manager, Birmingham district.

Black, Sivalls & Bryson, Inc., Jim Lawrence, Houston; Jon Young, Denver; Les Stillwell, Los Angeles; Jim Martin, Borger, Texas, controls division sales engineers.

Western Supply Company, W. F. Roberts, sales engineer, heat exchanger division, for the mid-continent area, based in Tulsa.

The Annin Company, Ross D. Randall, manager of engineering, Montebello, California.

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SOLVAY ALUMINUM CHLORIDE

Coarse screened. Medium screened. Fine screened. Extra fine grind. Which grade fits your needs?

Solvay® Aluminum Chloride is 99.5% pure or better. Meets rigid chemical specifications. Used for producing detergent intermediates and other alkylates . . . isomerization . . . polymerization . . . varied Friedel-Crafts syntheses.

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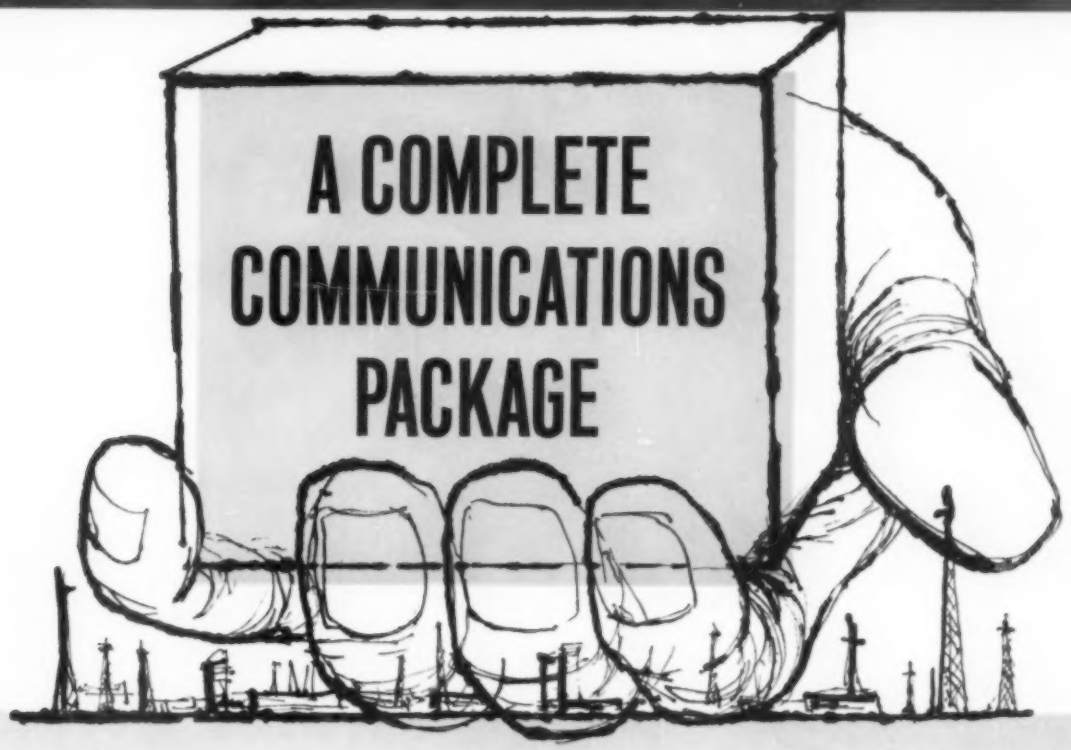
Engineering and Operating Section



Co-ordinated Systems of Communications and Control, including:

Private Automatic Exchanges – Dial-operated telephone systems for interoffice and intercity communications, including way-station dialing that puts everyone within instant reach.

Remote Control and Automation Equipment – Providing for scanning, telemetering and supervisory functions – to the degree of automation desirable *now* – or in the future!

Lenkurt Carrier and Microwave – Open-wire or cable carrier, and 6000-megacycle microwave radio, for communication and control over any distance, without additional line construction.

Station Equipment – Everything – but everything – you need, from drop wire and cable to telephone instruments.

The only short cut to communications efficiency and economy is single-source supply.

AUTOMATIC ELECTRIC offers this new dimension in communications for the oil and gas industry. The complete AUTOMATIC ELECTRIC package incorporates all types of communications equipment, custom-engineered, manufactured, and installed as ONE co-ordinated system – by ONE team of specialists, who accept complete responsibility. And, since you own the system, you hold complete operational and financial control of your communications in the palm of your hand.

Many oil companies are now utilizing AUTOMATIC ELECTRIC communications. Like to discuss what we might do for you? Just call or write Automatic Electric Sales Corporation, Northlake, Illinois (FIllmore 5-7111). Offices in principal cities.

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GENERAL SYSTEM

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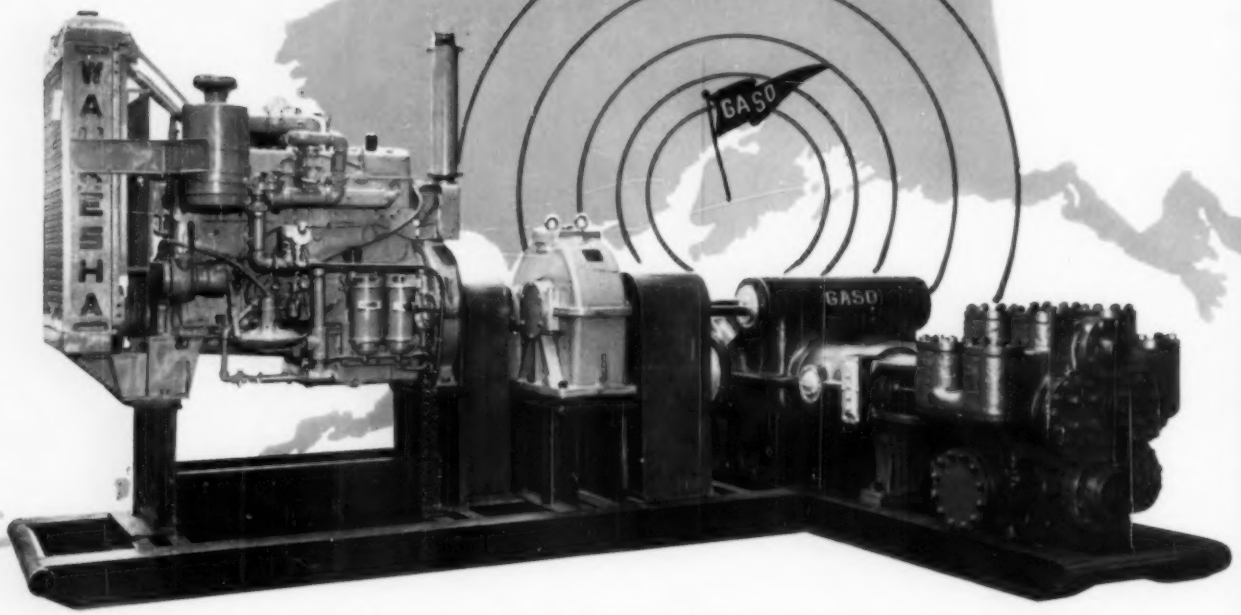

GASO PUMPS BRING GASO PERFORMANCE TO THE 49TH STATE

The photograph shows one of two Gaso Pumping Units delivered to the Kenai Pipe Line Company. The assembly consists of a Gaso Figure 2651, 5½"x12" Horizontal Duplex Piston Power Pump direct connected through a Lufkin 4.25 to 1 gear reducer to a Model 6-WAKBU Waukesha Oilfield Power Unit.

Normal operation calls for 435 barrels of crude oil per hour—10,440 barrels per day—at 500 pounds discharge. Under emergency conditions the pump will deliver the fluid at 950 pounds discharge.

The world-wide preference for Gaso Pumps stems from performance that speaks a language all pipe line engineers understand—a language of completely dependable service for longer periods of time, with less maintenance, all adding up to greater returns on the pumping investment.

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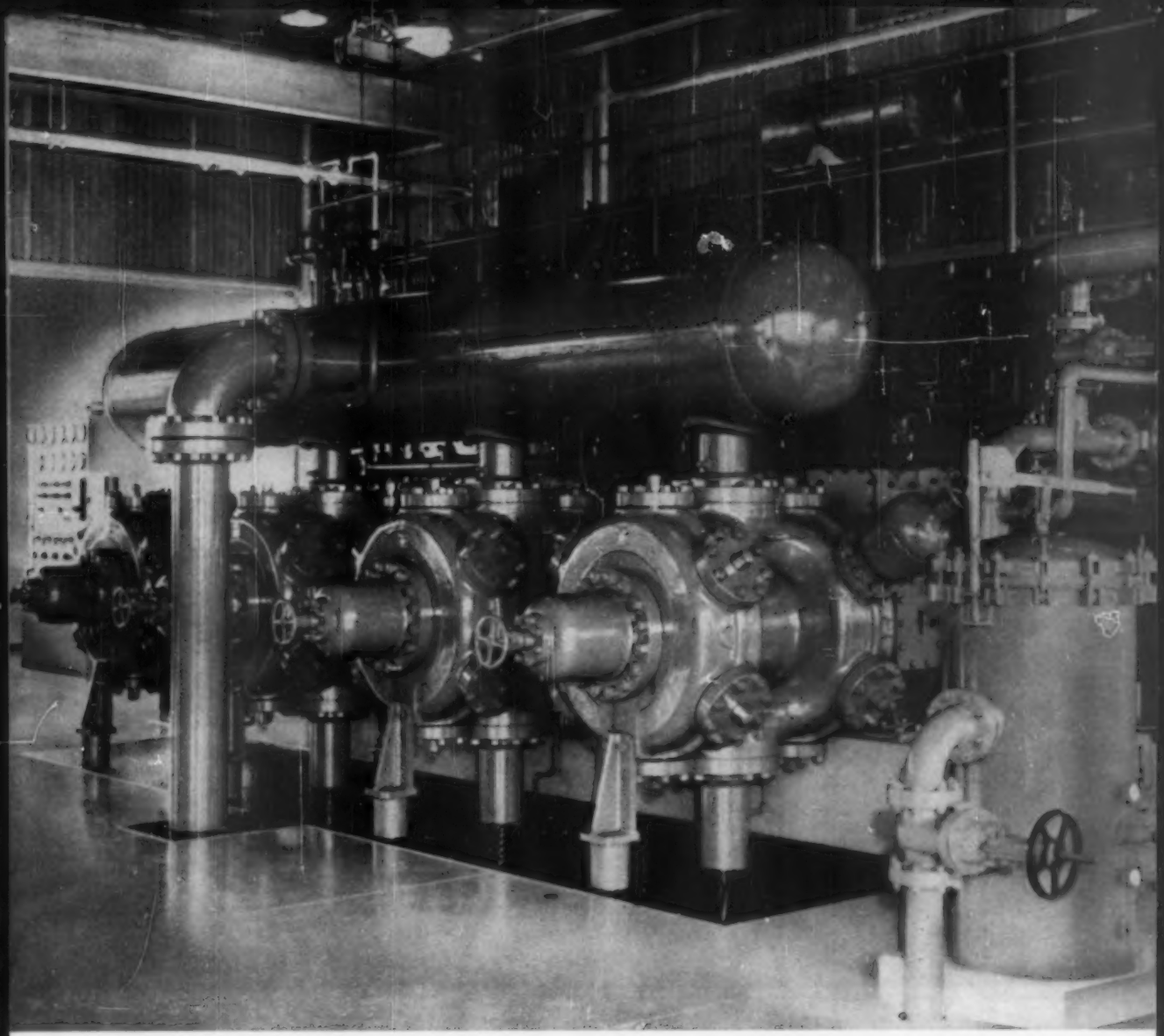
GASO PUMPS *for every oil industry need*

DISTRIBUTORS

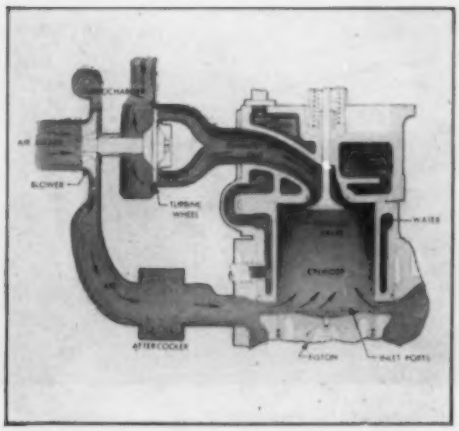
Farmington, N. M.—Gaso Pump & Burner Mfg. Co. • Shreveport, La., Odessa, Texas, Brookhaven and Tinsley, Miss.—W. L. Somner Company • Houston, Texas—Texas Pump & Compressor Company • Wichita Falls, Texas—Pump Engineering Co. • Evansville, Ind.—Hague Equipment Co., Inc. • Long Beach and Bakersfield, Cal.—Power Pumps, Inc. • Casper, Wyoming—Lufkin Foundry & Machine Co. • Edmonton, Alberta—Lufkin Machine Co., Ltd.

GASO PUMP & BURNER MFG. CO. First and Lansing Streets, Tulsa Oklahoma • Export Office: Empire State Building, New York, N. Y.



At Northern Natural's Clifton Station, this SUTC engine compressor operates

20 HOURS A DAY...FOR 3 STRAIGHT YEARS



Self-sustained turbocharging at any speed and load is possible because of SUTC's exclusive Uniflo scavenging.

Five years ago a remarkable new engine compressor was introduced.

Called the SUTC, this Worthington turbocharged 2-cycle engine compressor was unlike any other. Combustion air enters thru side inlet ports, *but the exhaust is thru overhead valves.* Valve timing can be arranged to give maximum supercharging effect.

On paper, straight-thru or "Uniflo" scavenging has many advantages. The turbocharger operates over the entire speed and load range without help from external sources. Scavenging efficiency is increased and pulsations practically eliminated.

Now came the real test. More than 130,000 hp were installed. Operators praised the SUTC's exceptionally smooth, quiet operation. Operational records confirm the machines reliability. Unit G-2312 is typical. This 8 cylinder, 2000 hp SUTC engine compressor was installed in 1957 in Northern Natural Gas Company's Clifton, Kansas Station. To date, it has logged over 20,000 hours—an average of more than 20 hours a day for 3 straight years. A sister unit installed last year has equalled this performance.

May we send you complete data on this unique engine compressor? Please write to H. C. Barten, Worthington Corporation, P.O. Box 953, Buffalo 5, N.Y.

WORTHINGTON

1 MODEL 28 AUTOMATIC SEND-RECEIVE SET (ASR)—facilities for sending and receiving messages plus tape punching and reading. With this unit, messages can be prepared in punched tape ahead of time, then transmitted automatically at maximum line speed. The ASR set incorporates the major components of the Model 28 line in a single, compact console.

2 MODEL 28 SEND-RECEIVE PAGE PRINTER—for sending messages directly from the keyboard and receiving incoming traffic. Both this unit and the automatic send-receive set accommodate multi-copy, marginally punched business forms as well as plain message paper. Horizontal tabulation and form positioning arrangements available.

3 MODEL 28 TAPE READER—reads punched tape and instantaneously transmits data. As with all Teletype sending units, data may go to one destination or a number of destinations simultaneously—either nearby or thousands of miles away.

4 MODEL 28 TAPE PUNCH—punches data in "common language" tape—also prints the data on the tape, for easy identification and handling. Used for message relaying, combining data from several sources on a single tape, or providing punched tape as a by-product of send-receive operations for later use with business machines.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Are Your Communications Fast Enough?

Have you checked your communications system recently? Is it fast enough? Is the information available to all who need it—when they need it? Examples: sales orders, purchase requisitions, invoices, inventory records, management reports, operating data of all kinds. Today, such documents and data dominate the scene—and profitability is often dependent upon how swiftly and efficiently they can be handled.

Teletype equipment surmounts distances. Whether your communications are primarily inter-departmental or extend across the Country—Teletype equipment will provide you with quick two-way communications, and a printed record at both ends.

Moreover, by using multi-copy, marginally punched business forms in Teletype printers in place of plain paper, transaction time is further speeded and much paper processing eliminated. A punched tape can be produced at the same time, automatically, for later use in business machines, conversion to cards, etc.

Teletype equipment can send out your information on a "broadcast" basis. With a single typing effort, your data or messages are transmitted to as many destinations as desired, simultaneously—so that everyone is kept up to date. Data can also be collected from many points in rotation, regardless of geographical separation. For example, a Teletype equipment network is an ideal adjunct to a centralized computer operation.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications. Can be used with Data-Phone and other communications services.

More Information. Write for descriptive brochure on Teletype Model 28 line to Dept. 92M, 5555 Touhy Avenue, Skokie, Illinois.

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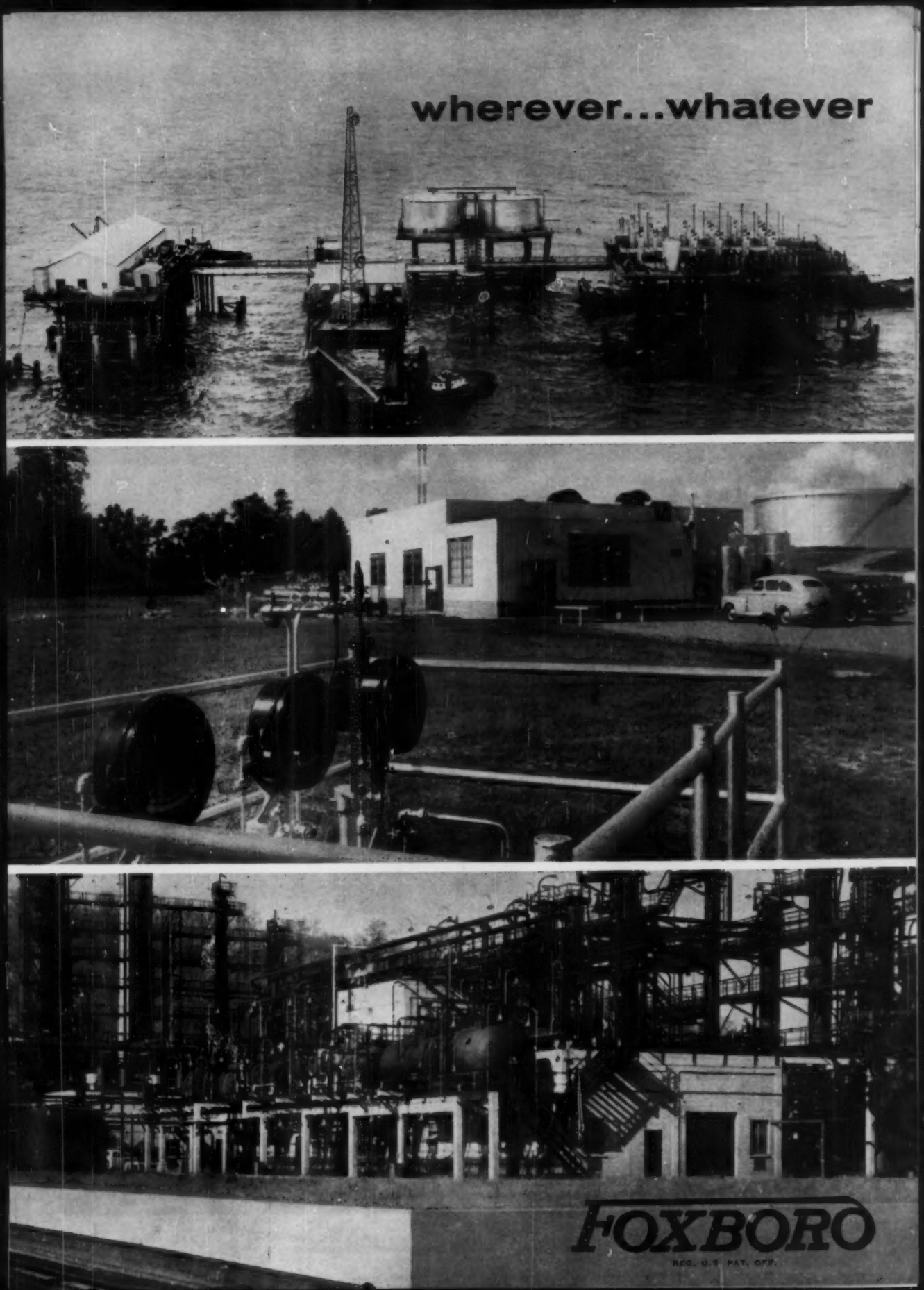
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FOXBORO
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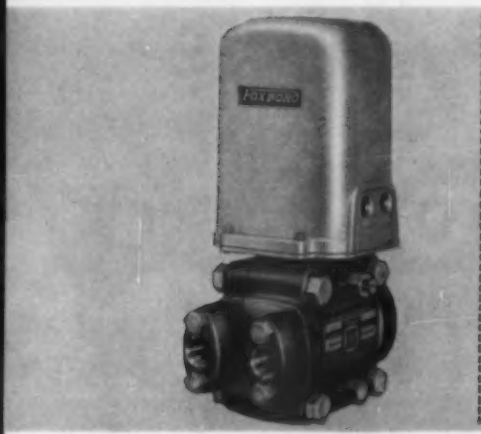
your flow problem

FOXBORO HAS A BETTER INSTRUMENT FOR IT

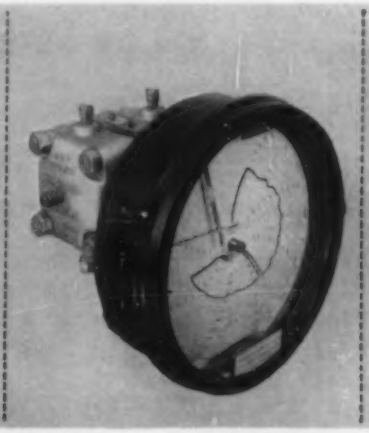
Liquid, vapor, gas, or slurry—there's a Foxboro instrument to meter the flow of any fluid in any oil and gas process. From the simplest general utility meter, to complex automatic ratio control systems, Foxboro offers the greatest variety of flow measurement and control equipment, assuring you of the right instrument for every flow problem.

Foxboro meters include superior accuracy, "cashregister" flow recorders; portable types for field checking; transmitters for long-distance, centralized control; as well as specially designed flow systems for even the most unusual needs.

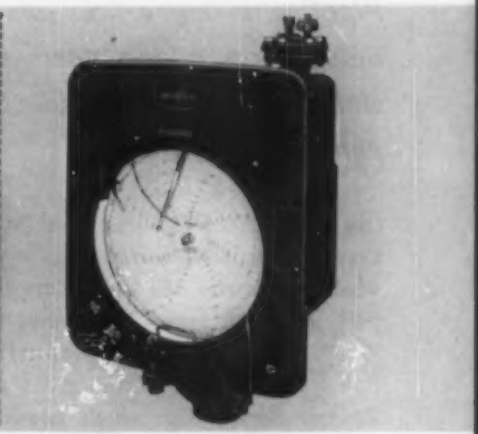
A few of these meters are described below. For complete information on these, or any meter in Foxboro's complete line of flow instrumentation, get in touch with your nearby Foxboro Field Engineer. Or write **The Foxboro Company, 3812 Norfolk Street, Foxboro, Mass.**



d/p CELL FLOW TRANSMITTER. Provides high sustained accuracy with positive overrange protection—complete line includes both pneumatic and tubeless electronic transmitters.



DIAPHRAGM METER. Uses no mercury—inherently linear, with NO zero drift. Round and rectangular cases. Available also as pneumatic or tubeless electronic transmitter.



MERCURY METER. Wide variety of types. Type 28 Meter, shown above, is ideal for gas flow metering. It has the longest float travel and the most power of any commercial meter made.

OTHER FOXBORO FLOW INSTRUMENTATION: Magnetic Flow Meters • Panel-, field-, and valve-mounted flow controllers • Electric, Pneumatic, and Mechanical Integrators • Planimeters • All primary elements, valves, and accessories required for complete flow measurement and control systems.

FIRST IN *FLOW*

Old Ocean Fuel Company builds 367-mile pipeline...

to meet needs of electric utility for huge quantities of natural gas

Pipeline to carry fuel gas from Old Ocean field to four of the steam-electric generating stations of the Texas Electric Service Company power system

Old Ocean Fuel Company, subsidiary of Texas Electric Service Company, has recently completed a gas pipeline which spans the 367 miles between the Old Ocean gas field in Brazoria and Matagorda Counties and the Fort Worth and Graham areas. Natural gas transported in this line will keep four of the great power plants of Texas Electric Service Company's power system humming.

A. O. Smith of Texas supplied 273 miles of 24-inch and approximately 24 miles of 20-inch "Made in Texas" pipe for this project. Since our first shipment of pipe in 1927, A. O. Smith has produced over 50,000 miles of large-diameter pipe. From our Milwaukee and Houston mills comes a dependable supply of pipe for almost every major pipeline project.

Through research ...a better way

A.O.Smith
CORPORATION
TUBULAR PRODUCTS DIVISION
Milwaukee 1, Wisconsin

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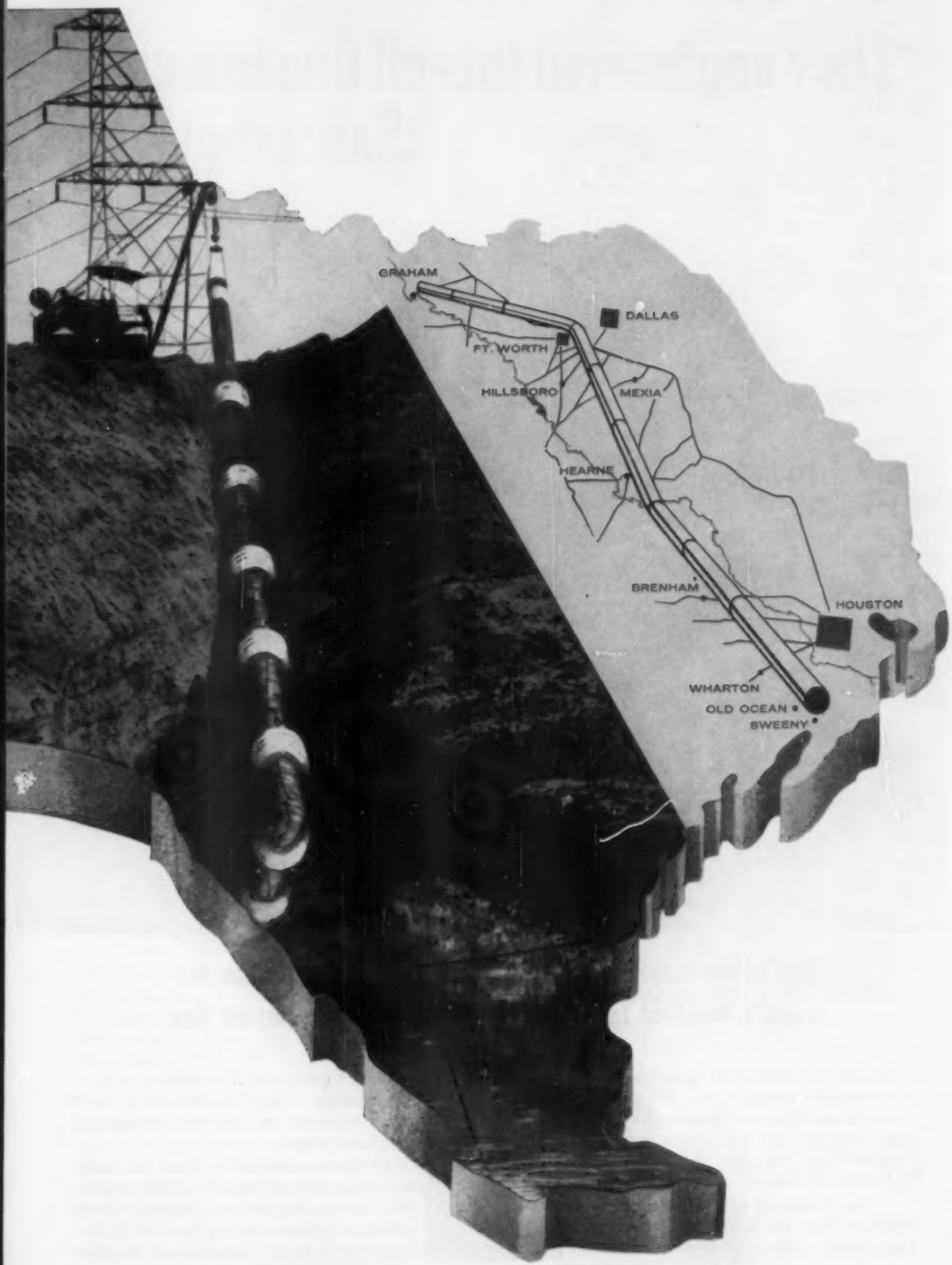
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SWEENY

"They engineered this oil line to a cat's then wrapped it

One of the world's largest pipeline operators chooses the world's toughest tape coating for new Patagonian oil line

A leading international pipeline company recently wrapped over 100 miles of crude oil gathering and transmission line with Polyken No. 960 Extra-Strength Pipeline Roll. The pipe ranges from 2 to 14 inches in diameter.

An Example of Perfection

The new line, which crosses part of the Patagonian plateau of southern Argentina, is an example of perfection in pipeline design. "They engineered it to a cat's whisker," is the way a seasoned pipeliner put it.

In their construction plans, the engineers specifically called for Polyken No. 960 Tape as the protective coating. Seven years of private testing and study had convinced these people that Polyken

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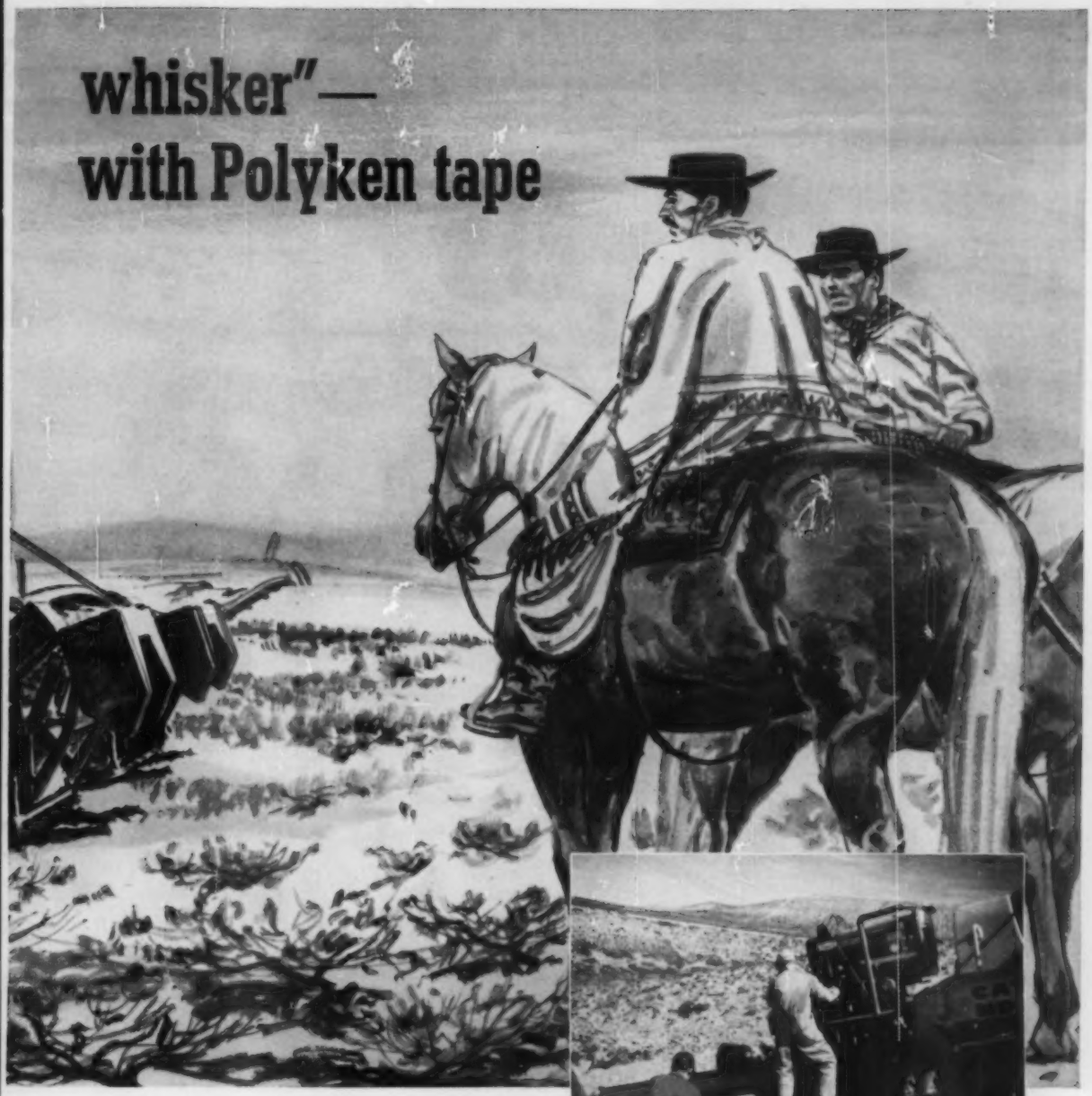

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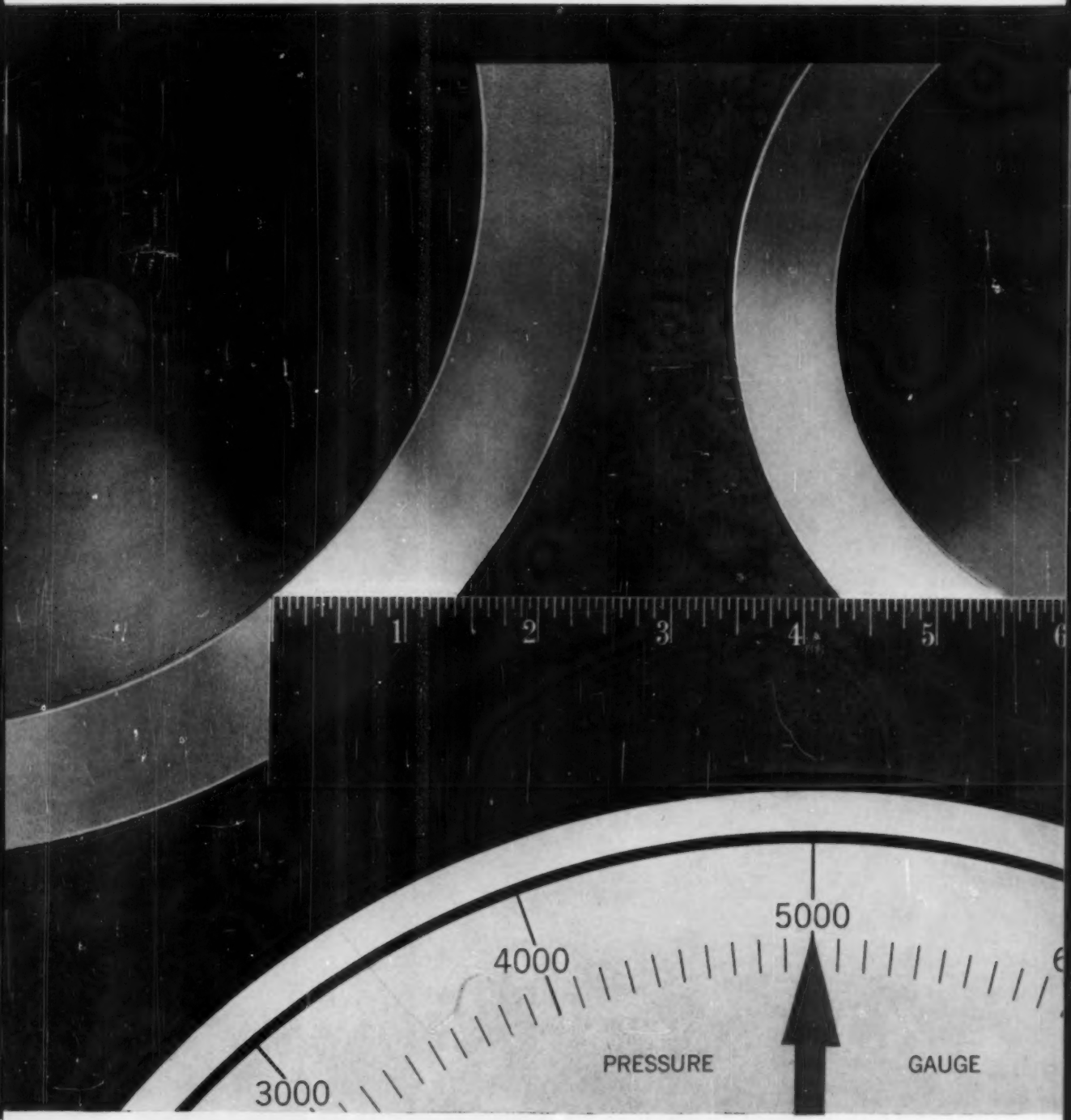

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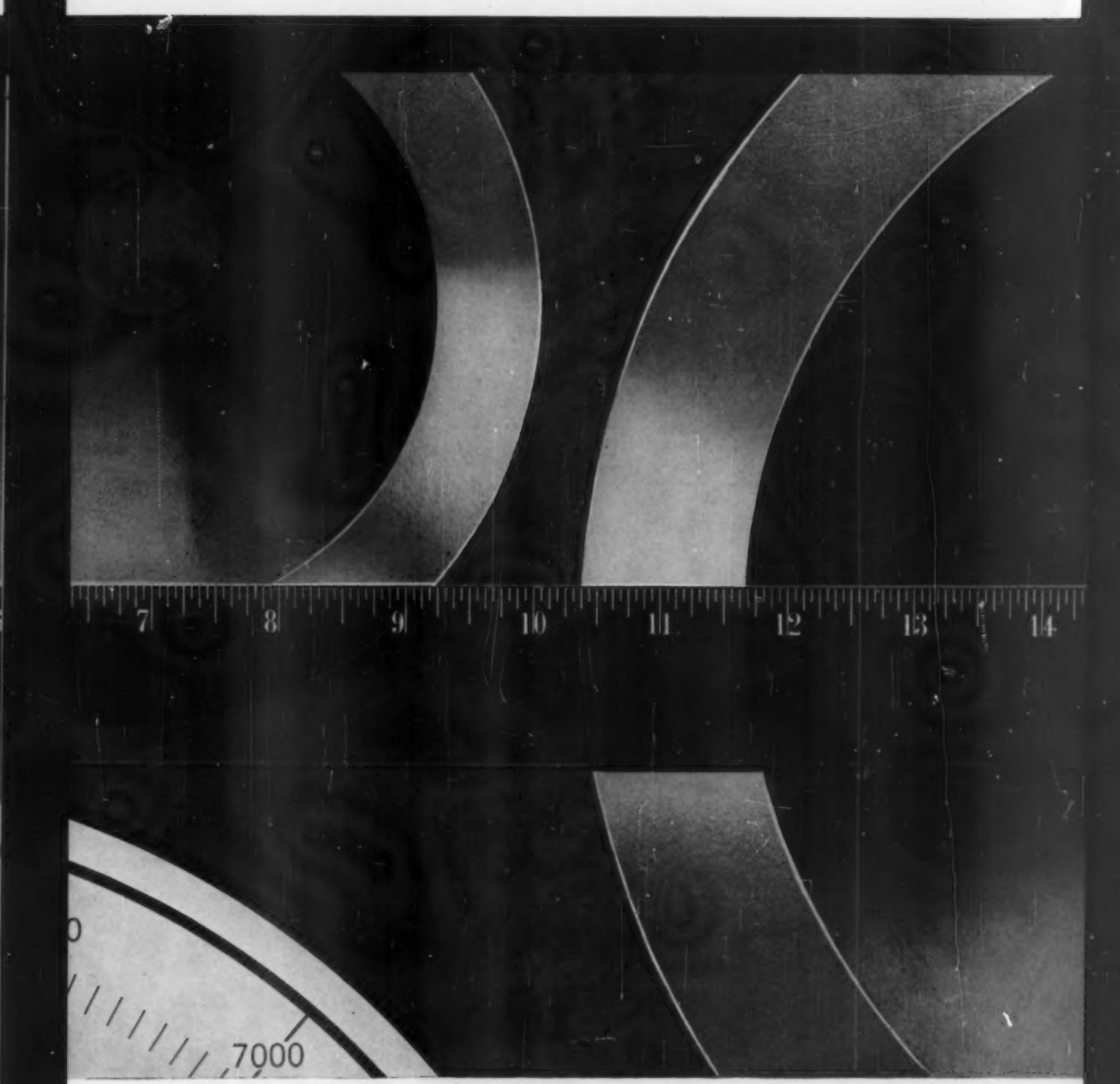

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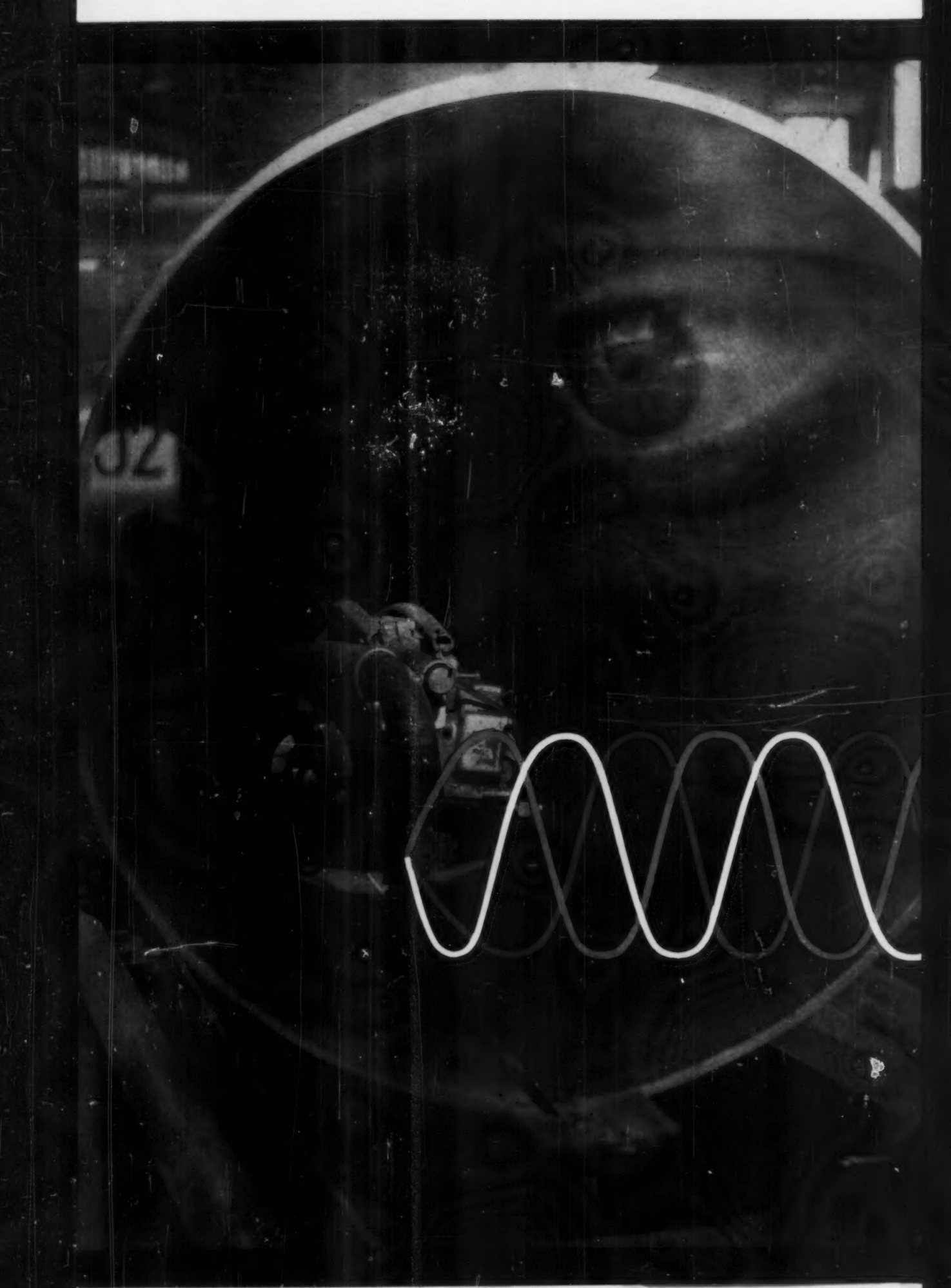

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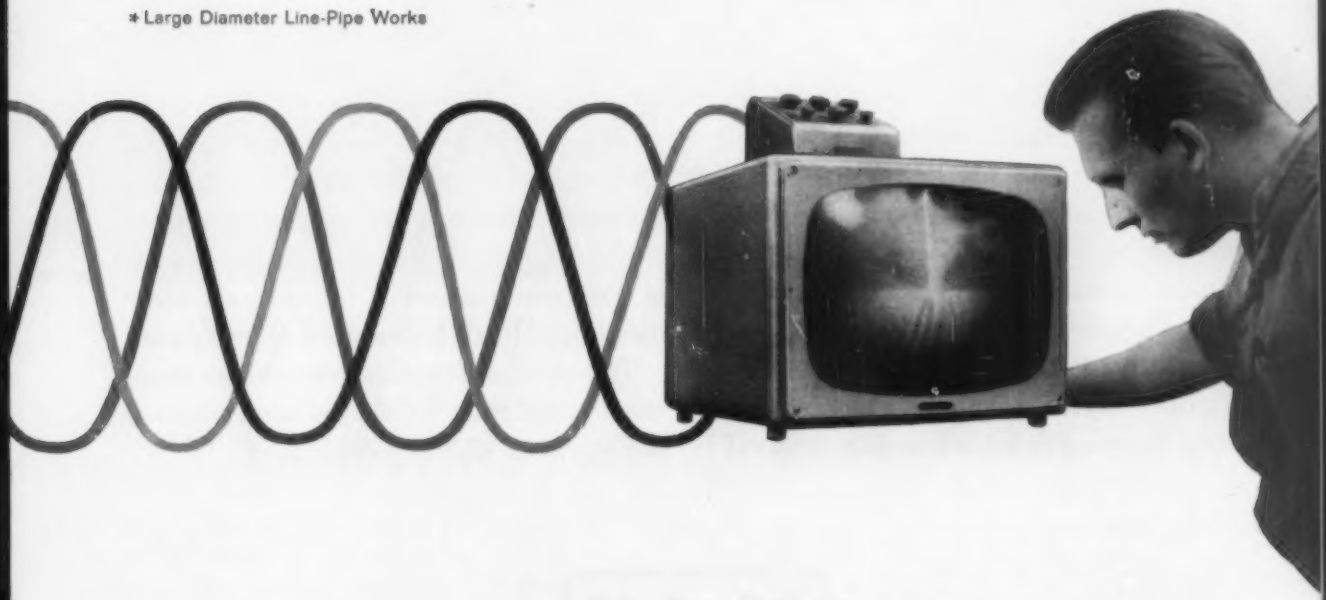

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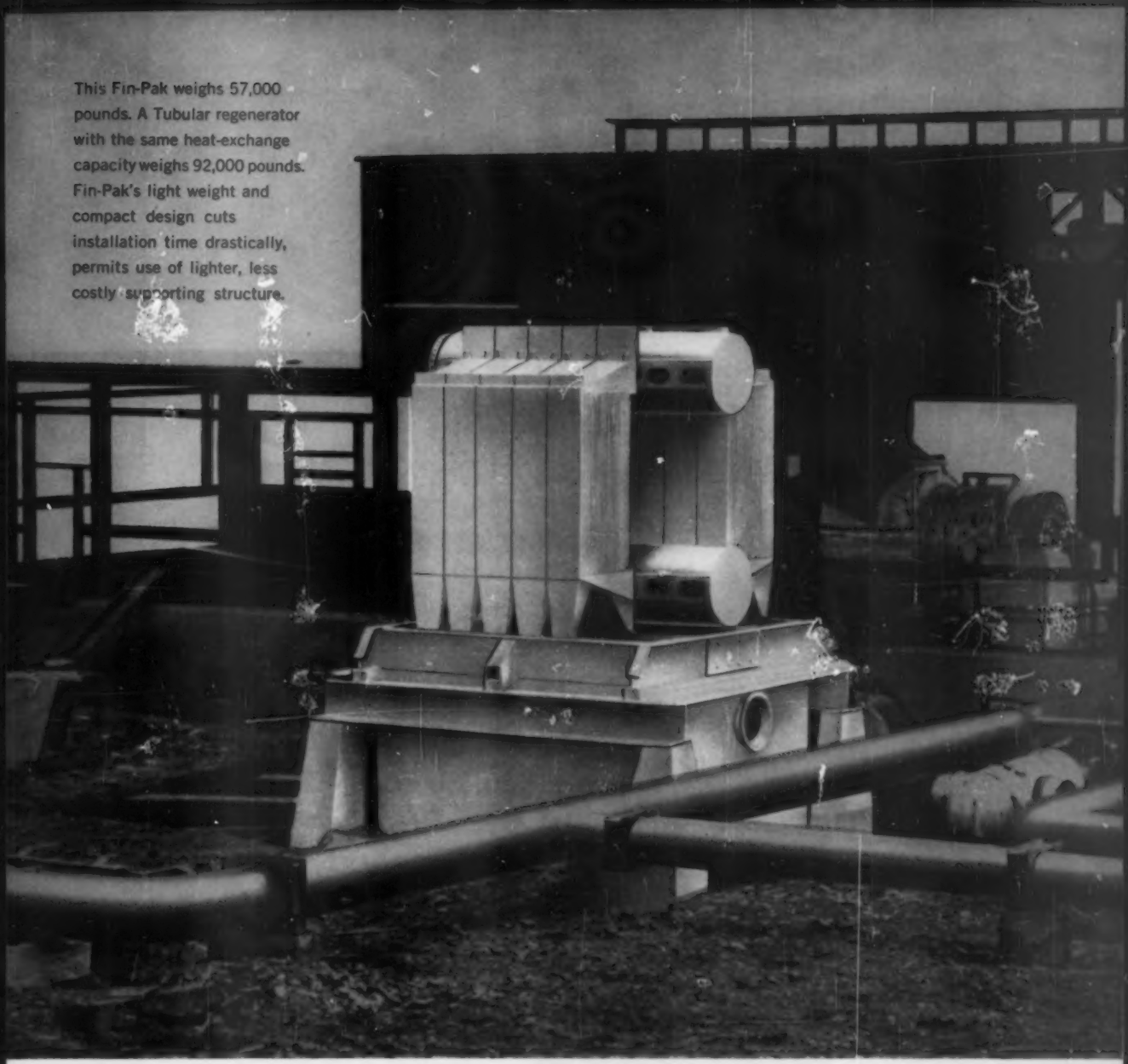
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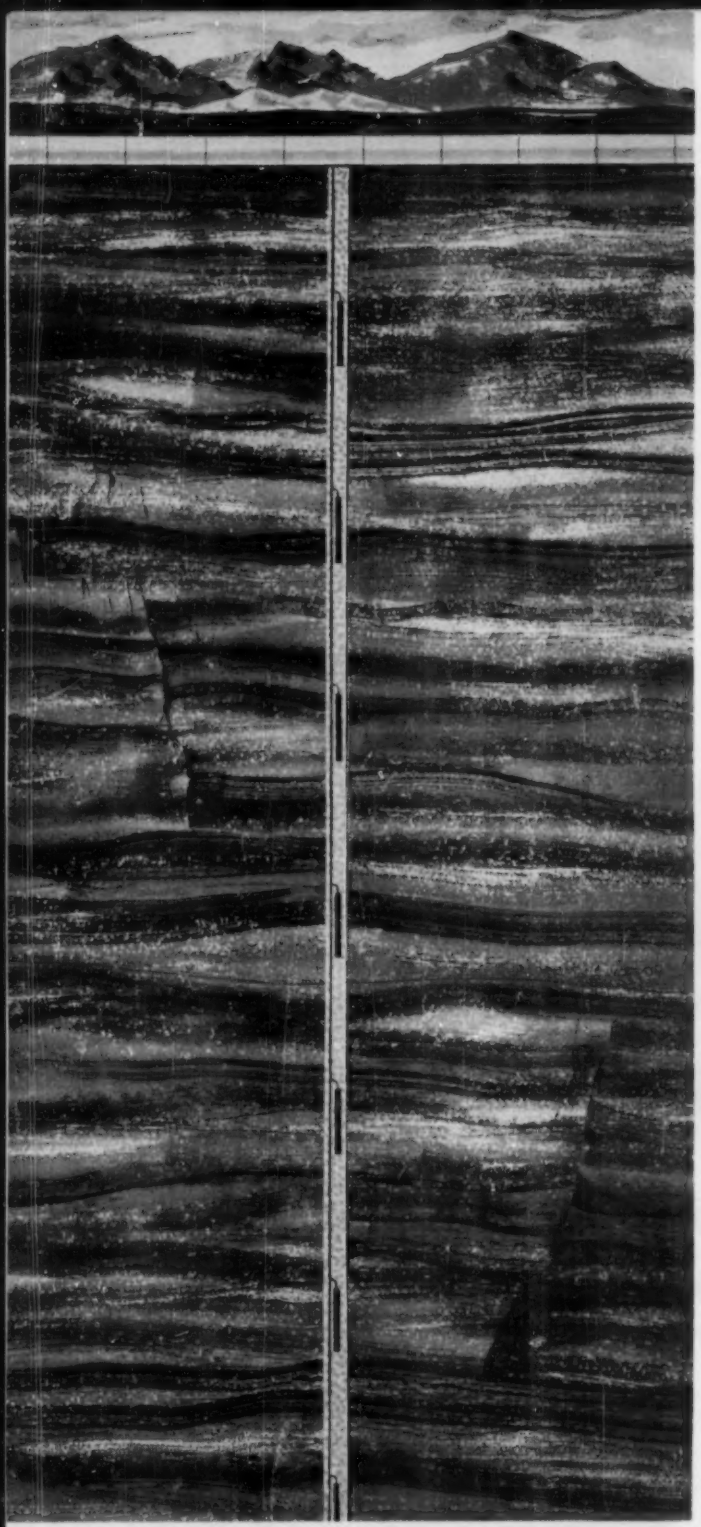

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BACTERIAL CORROSION

. . . A European Viewpoint

THE DISCOVERY that underground metal structures could be corroded by bacterial action was one of the surprises of the inter-war years.

The phenomenon was first traced and described in Holland, a country in which soil conditions are particularly suitable to it. The historical setting of this discovery is worth recalling.

After the first world war the Dutch authorities decided to make a vigorous attack on the problem of rural water supplies, until then rather neglected. In the North Holland peninsula a new system of water mains was laid to serve the small towns and villages north of Amsterdam. This is mostly "polder country," reclaimed land that a few hundred years before had been lagoon or marsh. The simple bitumen coating applied to the pipes afforded little protection and in two or three years they nearly all had to be replaced.

This salutary experience caused C. H. von Wolzogen Kühr and his colleagues in the water undertaking to investigate carefully the mechanism by which corrosion takes place in an air-free soil environment. Corrosion is, of course, basically an oxidation process and with the knowledge then available it would have seemed that a wet neutral clay bed, by excluding air, would have prevented corrosion quite effectively. In fact, corrosion proved to be much more severe under these conditions and Kühr showed that this was due to the activities of the sulfate-reducing bacterium, *Desulfovibrio desulfuricans*.

Since that time the significance of bacterial corrosion has been realized in most countries. Hadley,[1] for instance, pointed out that anaerobic bacteria are a major factor in anaerobic corrosion of pipelines in the United States. Also Kulman[2] (in 1953) showed there was evidence of bacterial anaerobic action in 81% of all the cases of severe corrosion reported. The year before, in London, Butlin, Vernon and Whiskin[3] had estimated the British figure to be "at least 70%."

There are at present two current theories as to how the corrosion is effected. Kühr[4] supposed that the corrosion equation $Fe + 2H_2O = Fe(OH)_2 + H_2$ was normally hindered by the accumulation of hydrogen on the cathodic areas and ferrous hydroxide on the anodic parts of the pipe. Moreover, insofar as electrolytic cells are responsible for corrosion, the presence of a film of nascent hydrogen alters the potential of the cathodic areas in such a way as tends to reduce the flow of current; the electrode becomes, in fact, "polarized." Anything that oxidizes the hydrogen away "depolarizes" the iron and enables corrosion to proceed; this is the function of the manganese dioxide paste in an ordinary dry cell.

Kühr thought that the bacteria effected this depolarization by transferring the oxygen from sulfates in the soil water to the hydrogen film, with the formation of water. The sulfides formed by the reduction of the sulfates also react with the $Fe(OH)_2$ to form FeS and, as this has a very low solubility in water, the above reaction is encouraged to go from left to right, i.e., the iron corrodes. This action of the anaerobic bacteria in removing the hydrogen film was given further emphasis by the extensive studies of Starkey and Wight.[5]

Wanklyn and Spruit,[6] working at Pretoria, South Africa, have put forward reasons for modifying this theory. Their experiments showed that bacteria did not accelerate the corrosion of iron unless some organic nutrient was present, even though a certain amount of sulfate reduction took place in its absence. When nutrient was present sulfate reduction took place far more quickly, and the amount of sulfide formed was far more (in proportion to the iron dissolved) than could be expained by Kühr's theory.

Wanklyn and Spruit therefore concluded that the bacteria accepted hydrogen from the organic nutrients, and the soluble sulfides formed were the main corrosive agency. They acted, not by depolarizing the cathodic areas, but by removing $Fe(OH)_2$ off the anodic areas, i.e., "anodic depolarization."

It was observed that some hydrogen from the cathodic areas was actually evolved into the atmosphere. The experi-

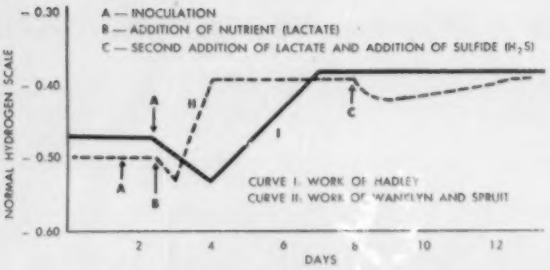


FIG. 1. Diagram showing effect of bacteria on potential of a piece of iron immersed in water. In Hadley's experiment organic nutrient was present from the beginning; Wanklyn and Spruit only added it at point "B." This shows that the effect of the bacteria in making the iron more negative depends on presence of organic food material. The actual potentials differ from those in Horvath and Solti experiments because different reference electrodes are used.

menters concluded that the utilization of nascent hydrogen by the bacteria was not a part of the corrosion process, but that the other part of Kühr's theory—the sulfiding of the hydroxide layer—was fully confirmed by their experiments . . . Fig. 1. Potentials measured with respect to hydrogen electrode.[7]

Various experimenters[6,7,9,10] have measured the electropotential of iron in contact with solutions containing sulfate-reducing bacteria. Iron immersed in such a solution is normally electronegative. Bacterial activity results in a lowered O-R potential. Normally the potential drops (becomes more negative) for a few days, then begins to climb and becomes stable at about 0.1 volt more positive than the initial reading.

The number of bacteria present seems to be at a maximum when the curve is at its minimum (most negative potential) and falls off as the curve climbs again; however, this may be partly due to the increasing alkalinity.

This pattern of behavior may be related to the periodicity noticed by Kirkov[8] in some quite different experiments using the current between two iron electrodes immersed in soil as a guide. One electrode was in an anaerobic and the other in an aerobic part of the same soil. He associated this periodic behavior with the repeated breakdown and rebuilding of the iron hydroxide film.

More recent experimental work on the potential of iron

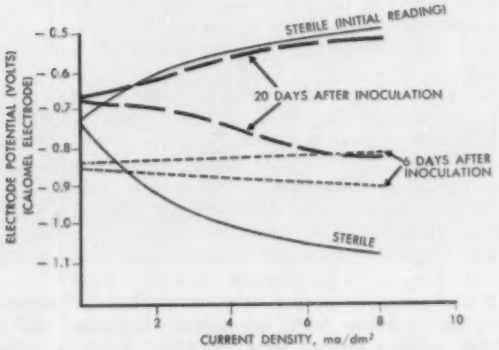


FIG. 2. Potential measurements on iron electrodes to which a difference of potential is applied. The wide spread of the "sterile" curves shows polarization; six days after inoculation with sulfate-reducing bacteria polarization is greatly reduced due to the depolarizing effect of the bacteria. (After Horvath and Solti. Ref. 10)

electrodes has been done in Hungary by Horvath and Solti.[9,10] In one test they passed a continuous current between two plates immersed in an anaerobic solution of neutral sulfates inoculated with sulfate-reducing bacteria. At the same time they measured the potential of the two electrodes for varying current flows relative to a calomel reference cell. This was repeated each day, and potentials of the two electrodes were plotted against current. The depolarizing effect of the solution showed itself most markedly at the end of six days, when bacterial counts showed the highest figures. After this the effect fell off. It was noteworthy that the effect on both positive and negative electrodes was the same, which would seem to support Kühr's original contention that depolarization occurs at both cathode and anode as a result of bacterial action (Fig. 2).

Although there is still much to be learned regarding the mechanism, the practical effects of anaerobic corrosion are not in dispute. Steel pipes develop fairly wide pits, which deepen until the wall is actually perforated by a slabbing effect. In the case of cast iron, "graphitization" takes place, i.e., the metallic iron is leached out, leaving behind a spongy mass consisting of graphite, iron carbide, iron oxide, and any other insoluble solids that may have been present. Iron sulfide is always present as a corrosive product of bacterial activity, but usually is not found touching the iron but a short distance away. The black color of this compound, and the characteristic evolution of H_2S when it is acidified, are the normal ways of detecting this type of corrosion. An alternate reduction and oxidation mechanism was discussed in reference[11] *Suggested Reading:* References 12 and 13.

The Organism

As far as is known, one species of bacterium is responsible for most of the anaerobic corrosion of iron, though it can take many different forms, and this led in the past to the idea that there were several species, basically, *Desulfovibrio desulfuricans* (Photo A) which is a single-celled creature about 1 micron wide and 4 microns long, with a flagellum at one end. It can also exist in a form with several flagella, and it can form a spiral up to 100 microns long. Certain strains, *D. aestuarii,* require salt water for growth. Another species, *D. rubentschikii,* was described some years ago in England.

There is a certain mystery about the species known as *D. rubentschikii,* for the original culture was lost and all subsequent attempts to isolate an organism having the properties attributed to it have failed.

Another species of *Desulfovibrio* was isolated and reported by the National Chemical Laboratory, Teddington, England in 1959.[24] This has been named *D. orientis* as it was first isolated from a sample of soil from Singapore. Under the microscope it appears as a curved rod, rather larger than many strains of the more common species, and it bears a number of flagella located all over the surface of the cell wall. Its corrosive effect is now being investigated at Teddington.

A third organism, known for many years as *Desulfovibrio thermodesulphuricans,* which can also influence corrosion, has been shown by later work to be identical with the well-known canned-food spoilage organism *Clostridium nigrificans.* It operates at much higher temperatures than are likely to be encountered in normal soil (a possible pipeline location is the exhaust side of compressor stations) and is here mentioned for the sake of completeness.

The bacterium *Desulfovibrio desulfuricans*, which, at least in temperate climates, is responsible for nearly all the damage to pipes in anaerobic situations, requires the following conditions for its activity:

1. There must be no oxygen
2. the pH must be above 5.5
3. Water, iron salts, and organic foodstuffs must be present
4. Sulfates are also essential

These are the conditions for activity. When they are not obtained the bacterium does not die, but goes into a passive phase in the soil. It may stay passive for many years, and quickly resume its former activity if the congenial conditions return.

A comprehensive review of sulfate-reducing bacteria, which discusses their physiology in detail and considers their importance in secondary flood waters, is given in the St. Bonaventure University symposium,[14] and a recent research project by J. O. Harris[15] has shown a high bacterial population in soils surrounding coated pipelines. This indicates the presence of organic food materials that can serve as a source of energy for sulfate-reducing bacteria. The paper by Harris[15] seems to be in line with general experience on this side of the Atlantic (for example, the work of Wanklyn and Spruit dealt with earlier).

Corrosion by Aerobic Bacteria

Kühr and his colleagues[13] noticed another form of corrosion is aerated soil, in which sulphur formed by the previous action of sulphate-reducers was oxidized by another bacillus, *Thiobacillus thiooxidans*. Sulphuric acid was formed and in a typical case the acid-wetted rind of corrosion products on the pipe had a pH of 4.7. Corrosion of this kind could therefore only occur in pipes that were alternately water-logged and dry at different times of the year. The thiooxidans organism is capable of living and functioning in very acid conditions, so in theory it can produce extremely low pH values.

PHOTO A — Desulfovibrio Desulfuricans — 40,000 magnifications — John Postgate Microbiological Research Establishment, England. Taken by A. C. Houwick Technische Hogeschool, Delft, Holland, June 1960.

In Britain, Ashmead[16] observed a similar action in coal mines waters. It was noticed that in some Scottish mines the water was extremely acid and ferruginous, causing much corrosion in the pipes that conveyed it. He showed that this acidity was due to the oxidation of pyrites by *T. thiooxidans*. Another species, *T. ferrooxidans*, was found to play a part in the process by oxidizing ferrous sulphate to the ferric salt, which then tends by hydrolysis to release free sulphuric acid. At this mine an analysis of the water showed a pH of 2.8 and an iron content of about 700 ppm, whereas water entering the coal measure from above was iron free and neutral. Ashmead's results are similar to those previously obtained in the USA by Leatham and others.[17]

It is not clear how important a role these organisms play in corrosion of underground pipe structure — apart from Kühr's observation there seems to be no definite recorded case of damage to pipelines by this mechanism.

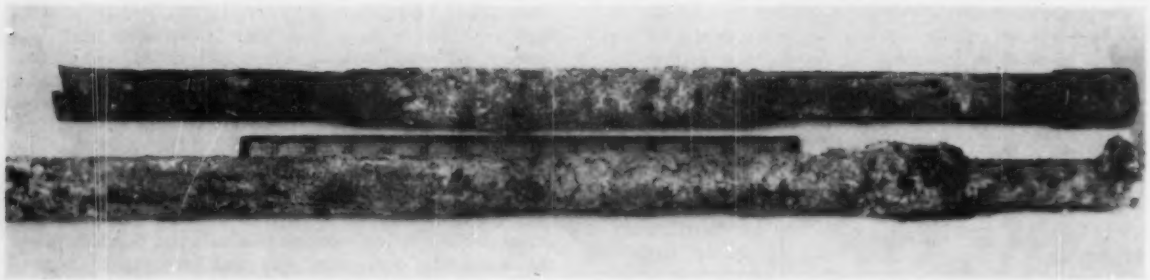
Inhibitors

Because so much harm is done by these tiny organisms, it is natural that one should seek some way of destroying them by poison. Some stimulus was given by the discovery of one or two cases when iron had apparently survived undamaged in an anaerobic soil environment for long periods of time. In the Hungate district of York, England, some Roman iron objects were found buried in the soil in a remarkable state of preservation. Farrer, Biek, and Wormwell[18] made a careful investigation, and concluded that the corrosion product was mostly iron phosphate, but contained some tannins (originating from a leather factory), which had prevented the sulfate-reducers from carrying out their destructive function. The phosphate was thought to come from animal excrement and the tannins from the peaty soil and the scraps of leather found on the site. The phosphate had, the investigators concluded, formed a protective coating on the iron and the tannin had inhibited the action of the sulfate-reducing bacteria, which were present in the soil but inactive.

Further tests on laboratory cultures indicated that some constituent of the soil that had contained leather cuttings definitely inhibited the activity of the bacteria. Tannic acid was the obvious explanation, and in fact 0.01% of this substance was found to completely inhibit bacterial activity and even 0.001% appeared to restrict it greatly.

Unfortunately, subsequent work at the National Chemical Laboratory (Teddington, England) has not confirmed this most promising result. In their report for 1958[19] they state that four different tannins had no effect on the growth of the sulfate-reducing organisms up to 0.1% provided that pH and Redox potential were adjusted to optimum conditions for bacterial growth. On the other hand, if conditions were less suitable, tannins had some inhibiting effect, and in some cases this inhibiting effect persisted when optimum environmental conditions were restored. Tannins may persist only a short time in many soils, however.

It will be seen from this that the position of tannins as bacterial inhibitors is at the moment rather obscure. The immunity from corrosion of the Hungate finds has yet to be explained, for the investigators were quite clear that the soil was anaerobic and neutral, and that sulfate-reducers were present.



A typical case of corrosion by sulfate-reducing bacteria. This gas service was taken from the ground ten years after it had been laid in an industrial area in the English Midlands. The soil was clay, containing clinker and shale. Tests showed the specific resistance to be low (1500 ohms/cm²), pH = 7.0 while both chloride (100 ppm) and sulfate (600 ppm) were high. In addition, the Woodhead test showed sulfate-reducing bacteria to be present in abundance.

An ever-present difficulty in the use of bacterial poisons is the leaching out that must occur if pipe coatings are continually subject to washing with soil water. Some degree of water solubility is essential if the bacteria are to be affected. A promising bactericide that has this property is now being sold in Britain under the name of "Panacide"[20] (di-chloro-dihydroxy-diphenyl-methane). This substance, which is also used for such purposes as the sterilizing of hospital blankets, has been shown to kill sulfate-reducers at concentrations of 5-10 ppm. The solubility, in neutral solution, is 30 ppm, so it would seem only partially resistant to the leaching action of soil water.

The effect of this substance on sulfate-reducers is already well established, for it is used successfully in Britain for the treatment of gas-holder tanks. In this case corrosion is not the major issue; the problem is that the reduction of sulfates in the water leads to the liberation of H_2S into the purified gas. Le Cornu[21] has described the use of this drug to treat the water of a large gas-holder at Fulham, London. It is important to note that only certain compounds are effective; some substances such as phenol, which are ordinarily regarded as bactericides, are quite ineffective against *Desulfovibrio* bacteria.

Other compounds that have been suggested as bactericides include "Chlordihexidine,"[22] which is effective but too expensive for ordinary commercial use, and "Cetrimide" (trimethyl-cetyl-ammonium-bromide), which is cheaper but still more expensive than "Panacide."

Another substance that has been suggested as "Lauryl pentachlorphenate," but this is difficult to use on account of its high toxicity to human beings. On the other hand, both "Cetrimide" and "Panacide" can be handled with perfect safety.

Practical Preventive Measures

The Benelux Corrosion Committee has published two questionnaires,[23] the one for water and the other for gas pipes, which are remarkable for their thoroughness. This is part of a campaign for more information on the causes of corrosion and on the effectiveness of various preventive measures. National corrosion committees were set up, and now a regular "mixed" committee has been formed representing Germany, France, and the Benelux countries.

The questionnaires (which are available in printed form in the English language and can be obtained from Dr. J. E. Carriere, Van Speykstraat—34—The Hague, Holland) deal with: (a) General data—nature of metal, nature of protection, etc.; (b) detailed data about pipelines — dimensions, method of manufacture, precise details of coatings; (c) characteristics of the soil and soil water—analysis, pH, Redox-potential, conductivity, etc.; (d) composition of the gas (or water) carried; (e) data concerning cathodic protection; (f) results of inspecting the outside; (g) results of inspecting the inside; (h) leak statistics.

It is thought that if these details are filled in for a number of pipelines in different countries, and particularly if a systematic policy of digging up and inspecting pipes is carried out with it, a coordinated body of information will be built up. This standardized procedure does not yet seem to have spread beyond the limits of these five countries, and in Britain at least reports are still regrettably less comprehensive.

Many undertakings have a system of soil testing designed to indicate what kind of protection will be needed on a new pipeline. Gaz de France maintains a central laboratory

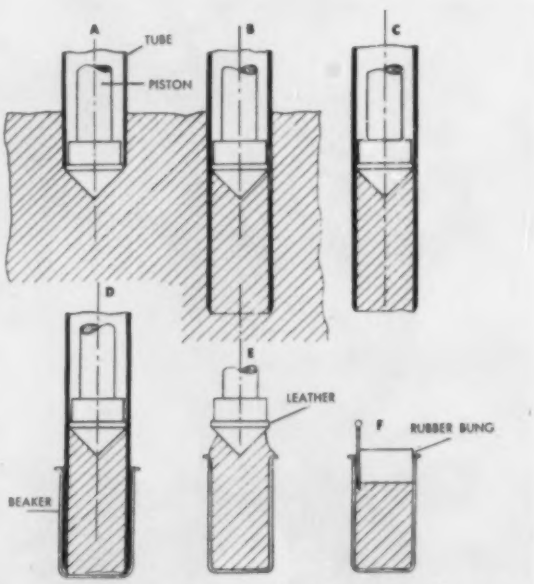


FIG. 3. A modification of the Starkey and Wight's Redox potential method, by Dutch chemists.

A. Tube with piston in position, pushed a short way into the ground.
B. Piston stays in position, tube is driven into ground.
C. Tube, piston, and soil sample taken out together.
D. Glass beaker placed over the end of tube.
E. Tube slowly withdrawn, glass walls keep air out.
F. Top earth removed, rubber bung pressed down. The quill is removed when bung and soil meet, and sample can then be kept for a week or more before Redox potential is measured in laboratory.

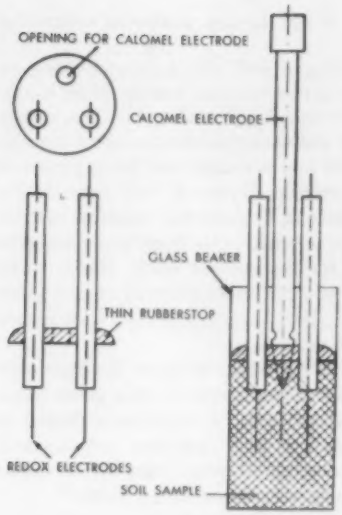


FIG. 4. To measure the Redox potential by the Dutch chemists modification in the laboratory the rubber stopper ("F" in Fig. 3) is removed and quickly replaced by a thin stopper through which the electrodes have been inserted.

for soil surveys, and there are similar institutions in Belgium and Holland.

In the latter country, Dutch chemists have developed a modification of Starkey and Wight's Redox potential method,[24] which avoids the necessity of carrying delicate apparatus into the field. Samples of soil are removed by a special auger that prevents access of air to the sample. The soil is then sealed up in a beaker, and measurements of the oxidation potential can be made in the laboratory at leisure. Tests made in Delft, Holland, at the Corrosion Institute (now the Metal Institute) showed good agreement between the American and the Dutch method, and also a reasonable correlation with corrosivity (Fig. 3 and 4). The development of the Redox Probe, Carl Deuber,[25] and the practical field application and data collected by Costanzo and McVey,[26, 27] form the basis of comparative results.

In Birmingham, England, the West Midlands Gas Board[28] takes samples of soil both on the line of the pipe and also 2 ft to the side. They ascertain: (1) electrical resistivity both of the sample as taken and after wetting and draining to a prescribed schedule; (2) sulfate ions; (3) chloride ions; (4) pH; (5) presence of sulfate-reducers based on a test described by Woodhead in 1941.[29]

In this latter test a sample of soil is incubated in a sealed flask over an inert atmosphere in a sterilized neutral nutrient solution containing iron salt at 30 C. If black ferrous sulfide appears in three days or less, bacterial contamination is regarded as heavy; if it takes 21 days or more to form, contamination is light (Fig. 6).

An interesting feature of this test is that, when soils are being examined, two bottles are prepared, one receiving 0.5 grams and the other 2.0 grams of the soil. Normally the amount of sulfide formed is roughly in the proportion of the weight of samples used, but if the reverse should be the case, it is held to indicate that some bacterial inhibitors are present in the soil. T. A. Dick[28] records one such case on the Coleshill Bypass Road in Birmingham, but no further research was undertaken to discover the nature of the inhibitors. Until this question has been followed up, this type of experimental result will no doubt be received with caution.

Practical Measures — Pipe Protection

The forms of protective coating employed generally to prevent corrosion are mostly effective against bacterial corrosion, insofar as they act by excluding water from contact with the metal surface. By far the most common waterproofing material used in Europe is bitumen, and this was formerly given resilience by the use of some supporting cellulose structure, such as hessian, jute, or cotton. A realization of the important part played by bacteria has led to a great reduction in the use of such organic materials. There seems little doubt that the supporting fiber has decomposed to simpler organic compounds, thus giving nutriment to the very bacteria that are most damaging to the metal of the pipe. Thus the Dutch specifications for the bitumen coating of pipes, dated 1948 and 1949,[30] which were taken as a standard in countries outside Holland, are now being revised to eliminate jute and such organic supporting materials. In Europe generally, glass cloth, glass felt, and even nylon are being used generally as a reinforcement, and asbestos felts for shielding for bituminous coatings.

Yet another possibility is that the backfill shall be arranged to reduce the likelihood of anaerobic conditions existing. Some gas undertakings in Britain place considerable emphasis on this type of solution.[28] If the soil is found to be aggressive, washed gravel is used as a backfill and the soil that has been dug out is dumped elsewhere. On occasion chalk is used as a backfill, although no evidence is available to indicate that the soil can be made alkaline enough to discourage the bacteria.

The efficacy of the drainage technique is also not gen-

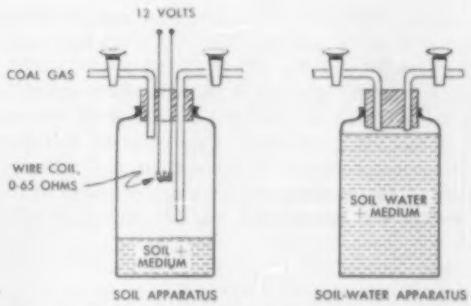


FIG. 5. The Woodhead test for the presence of sulfate-reducing bacteria in soil or soil water. The electrically-heated coil is provided to eliminate any oxygen in the coal gas. (After Dick, Ref. 28)

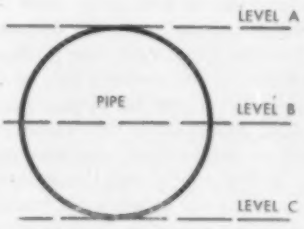


FIG. 6. Redox potential at a distance from the pipe of:

	Millivolts					
	0 cm	5 cm	10 cm	15 cm	20 cm	50 cm
Level A	+400	—	+550	—	+575	—
Level B	+525	+530	+580	+530	+565	+495
Level C	+225	+280	—	—	+490	+520

Situation: Gravel soil, pH 7.0. Usquert (Groningen) Holland. (After Boon, Ref. 31.)

erally agreed upon. Tests made in Essex, England, on a water main showed that the chief result of filling in a clay trench with gravel was to construct a surface drain into which all the water from the surrounding soil flowed; the trench was then still anaerobic.

J. W. Boon, in Delft, Holland,[31] has made a recent study of the permeability of soils to air. He examined soil all around the circumference of a buried pipe, and found that although on top and to the sides the soil was often aerobic (Redox over +400, hydrogen scale) the soil close to the metal on the underside might well be anaerobic (Redox in the region of 200). It is, of course, just at this place that corrosion most commonly occurs. This certainly suggests that it will be very difficult to prevent anaerobic conditions by control of backfill (Fig. 6).

The work of Dr. J. O. Harris of Kansas State University[15] has shown that by the conventional backfilling operations with bulldozers, morman boards, etc., large amounts of organic nutriment from the surface layers of the soil from the spoil bank are transferred to the neighborhood of the pipe. Similar observations have been made in Holland and Belgium, though in this case it was particularly plant roots that were drawing attention to the matter. Plant roots, like bacteria, are attracted to humus, and it has been noticed that when the backfilling is controlled by screening or by use of mobile equipment to select backfill to prevent surface soil going to the bottom of the trench less trouble is experienced.

Cathodic Protection

Cathodic protection no doubt is an effective protection against microbiological corrosion, but it has been suggested by Wormwell[11] that the voltage should be minus 0.95 volts if heavy bacterial infection is present. More recently, Horvath, and Solti[9] have stated that if minus 0.92 volts is used, 95% protection is obtained. They observed that the voltage required fluctuates from day to day with varying activity of the bacteria, but it is not desirable to step up the voltage too strongly for fear of creating an alkalinity close to the pipe that would damage and cause unbonding of the coating.

Comparing the European with the American literature one is struck by the fact that whereas coal-tar pitch is preferred in the U.S.A., Europe has been using bitumen, mostly because the plasticized and semi-plasticized coal-tar enamels have not been available and are only now being produced in small quantities currently. However, very recently the South Eastern Gas Board in England has begun to use this type of coating on a large scale, using finely powdered coal dust as a plasticizer for the coal-tar pitch. Harris[15] and McComb[32] show the tendency of bitumen to absorb water and to be attacked by bacterial action, but there is no record of this in European literature.

A layer of cement on top of the bitumen has been used to some extent in Holland, and seems to have given excellent results in water-logged soils. A water-main treated in this way, which was laid in 1928 in a very wet clay soil, was still in excellent condition 18 years later, but no report has yet been forthcoming as to its condition today.[33]

The fight of men against corrosion is spread over a world-wide battlefield, and there seems everything to be gained by a more thoroughgoing exchange of views across the Continents. The author would like to express his gratitude to the many workers both in Britain and on the Continent who have helped him to collect the facts assembled in this report.

ABOUT THE AUTHOR

Leslie T. Minchin was born in London, Great Britain, in 1906 and graduated in chemistry and physics at London University in 1927. For some 20 years he was a research chemist in the gas utilization laboratories of the Gas Light and Coke Company, which at that time served the northern half of the London area. During this period he carried out researches on corrosion, illumination, and flame. Since 1946 he has been an independent consultant and scientific journalist, dealing mostly with combustion problems in the gas industry but retaining his interest on other subjects, including corrosion. He was made a Fellow of the Institute of Fuel in 1955 in recognition of his outstanding work on flame and combustion. Throughout his career he has paid particular attention to the work of Continental scientists, and has many contacts in adjacent countries. In this article he summarizes Western European experience on the bacterial corrosion of pipes.

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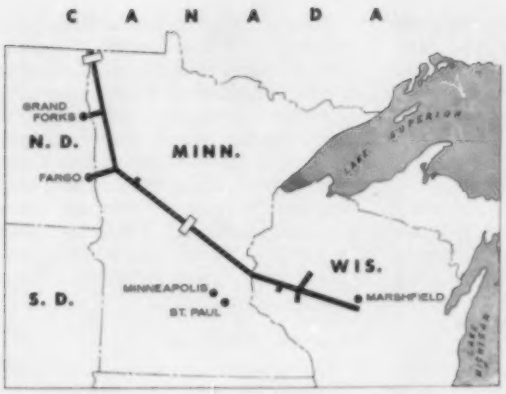


New Midwestern line connects with Trans-Canada on Minnesota-Canadian border south of Winnipeg and terminates near Marshfield, Wisconsin.

Midwestern system completed ahead of schedule . . . capacity 204,000,000 cu ft a day.

Upper Midwest gets . . .

CANADIAN GAS

Valves being installed on the dual crossing of the St. Croix River.

MIDWESTERN GAS Transmission Company, a subsidiary of Tennessee Gas Transmission Company, has begun operation of its new pipeline providing the upper Midwest with a major new supply of natural gas.

The 504-mile, 24-in. (main line) pipeline has the capacity to transport 204,000,000 cu ft per day of natural gas from the prolific fields of western Canada.

Midwestern purchases the gas from Trans-Canada Pipe Lines, Ltd., which operates a pipeline from Alberta to Eastern Canada, at a point on the Minnesota-Canadian border south of Winnipeg. Midwestern's line runs southeast from that point through Minnesota and Wisconsin, terminating near Marshfield, Wisconsin, at a connection with pipeline facilities constructed by Michigan Wisconsin Pipe Line Company.

The bulk of the gas — 158,000,000 cu ft per day — is delivered near Marshfield to Michigan Wisconsin Pipe Line Company. Northern States Power Company of Minneapolis receives approximately 30,000,000 cu ft per day from Midwestern, extending natural gas service to eight cities and towns Northern States previously served with manufactured gas. They are: Grand Forks and Fargo, North Dakota; East Grand Forks, Moorhead, and Dilworth, Minnesota; and Eau Claire, Chippewa Falls, and Menomonie, Wisconsin.

In addition, Montana-Dakota Utilities Company receives 4,000,000 cu ft per day for Crookston, Minnesota, and United Petroleum Gas Com-

pany 1,800,000 cu ft per day for Detroit Lakes and Ada, Minnesota. Also, Midwestern provides direct service to seven communities: Perham, Hawley, Argyle, Frazee, Lake Park, New York Mills, and Stephen.

Construction Contracts

Midwestern contracts for the main pipeline were as follows: A 155-mile section from the Canadian border to the Becker County-Clay County line in Minnesota, to Bechtel Corporation; 54 miles from the Becker County-Clay County line to near New York Mills, Minnesota, to Grayco Constructors, Inc.; 56 miles, from New York Mills to the Mississippi River, to H. C. Price Company; 109 miles from the Mississippi River to Wanderoos, Wisconsin, to the Houston Contracting Company; 54 miles, from Wanderoos to the Chippewa River, to the Contracting and Material Company; and 66 miles, from the Chippewa River to Marshfield, Wisconsin, to Panama, Inc.

Sixteen miles of lateral lines were awarded to Texas Pipeline Construction, Inc., and 39 miles of lateral lines to the Bristow-Hyde Engineering Corporation. Crossings of three rivers were constructed as follows: the Mississippi, by Popich-Marine Construction Company; the St. Croix, by Pentzien, Inc., and the Chippewa, by Missouri Valley Dredging Company. Two compressor stations, at Hallock and Staples, Minnesota, were built by Houston Contracting Company.

Exceed Schedule

Construction of the $52,000,000 Midwestern system was completed well ahead of the November 1 target date, as pipe laying crews took advantage of the long summer daylight hours and the generally favorable terrain.

Of course, not all the ditching was routine. In the rich farmland of the Red River Valley of the North, Midwestern specified 36-in. cover to protect the line against deep plowing. Some spreads encountered peat bogs and hunting and fishing areas, necessitating weighting of the line through boggy areas and detours to avoid disturbing favorite vacation areas.

And the Midwestern line construction involved crossing more than 260 roads, 26 U. S. highways, 26 railroad lines, and one other pipeline system in two places. Conventional crossing methods were used.

Since this area is noted for its chilly winters, Midwestern specified that any fittings, pipe or valves above ground were to be "charpy-tested" for minus 50 F, thus minimizing cold-weather maintenance problems.

Pipe Coated Internally

All the 24-in. main line pipe received an internal coating of an epoxy-resin before installation to improve the line's deliverability. No bending or welding problems were noted with the coated pipe.

Internal coating was performed by Rosson-Richards Processing Company of Houston, Hill-Hubbell & Company of Houston, L. C. Russell Company Inc. of Beaumont, and by Republic Steel through its sub-contractors.

A minimum dry thickness of 1.5 mils was specified for all 24-in. pipe internal coating except for seamless pipe, which received coating with a dry thickness of 2.0 mils.

All pipe moved routinely from the mills to storage areas by rail, with the exception of that supplied from Orange, Texas, which made a 30-day Mississippi River barge journey to Minneapolis, completing its travels by railroad.

Dunn Brothers, Inc., of Dallas, and J. O. Willett Pipeline Stringing Company of Monroe, Louisiana, did the pipe stringing along the right-of-way.

External Protection

Three major types of external wrappings were used:

A 155-mile section of the line was wrapped with a 20-mil butyl rubber polyvinyl chloride tape with a butyl rubber primer, and a 40-50-40 kraft paper exterior.

Petroleum wax covered by a 20-mil plastic wrapper and an 80-lb kraft paper outer wrap was used for 118 miles of the system. Total thickness of this covering is 30 mils.

For 151 miles, a 3/32-in. semi-plasticized coal-tar enamel, with a glass outer wrap, was employed.

Approximately 70 miles of the line were externally coated with an elevated-temperature coal-tar enamel with a glass outer wrap. This wrapping, 3/32 in. thick, was specified for use for one valve section downstream from compressor stations except in areas where

Attaching concrete weights to line crossing peat bog in Minnesota.

butyl rubber tape was used, since both this enamel and the tape are heat-resistant.

The heavy-wall, seamless pipe used for river crossings was protected with a double coat of the semi-plasticized coal-tar enamel.

At the three major dual 24-in. river crossings, 5000-lb bolt-on concrete weights were used. The unusually heavy aggregated concrete, weighing 210 lb per cu ft, was manufactured by Anchor-Wate Company and Rosson-Richards Construction Company.

Laterals ranging from 3 to 8 in. in outside diameter and totaling 55 miles in length, were extended to Menomonie, Chippewa Falls, and Eau Claire in Wisconsin, to Grand Forks and Fargo, North Dakota, and to the Minnesota cities of Moorhead, Ada, Detroit Lakes, and Dilworth.

Some Pipe Double-Jointed

In areas where the terrain permitted, the pipe was double jointed before delivery to the right-of-way. The H. C. Price Company, using its submerged arc automatic welding machine, double-jointed 40-ft sections for 154 miles of the system at Midwestern's Minnesota pipe storage sites. Republic Steel made 60-ft sections from 30-ft lengths at its pipe mill.

Main line pipe was 24-in. OD by 0.281-in. wall thickness, and the seamless heavy wall pipe was 24-in. OD by 0.406-in.

One hundred percent circumferential X-ray inspection was called for on all river crossings and other submerged pipe. A 30% minimum coverage was specified on all mainline spreads, and 100% X-ray for all double-jointing was required by Midwestern. X-ray inspection was by Industrial X-Ray Engineers and Houston Gamma Ray Company, both Houston firms.

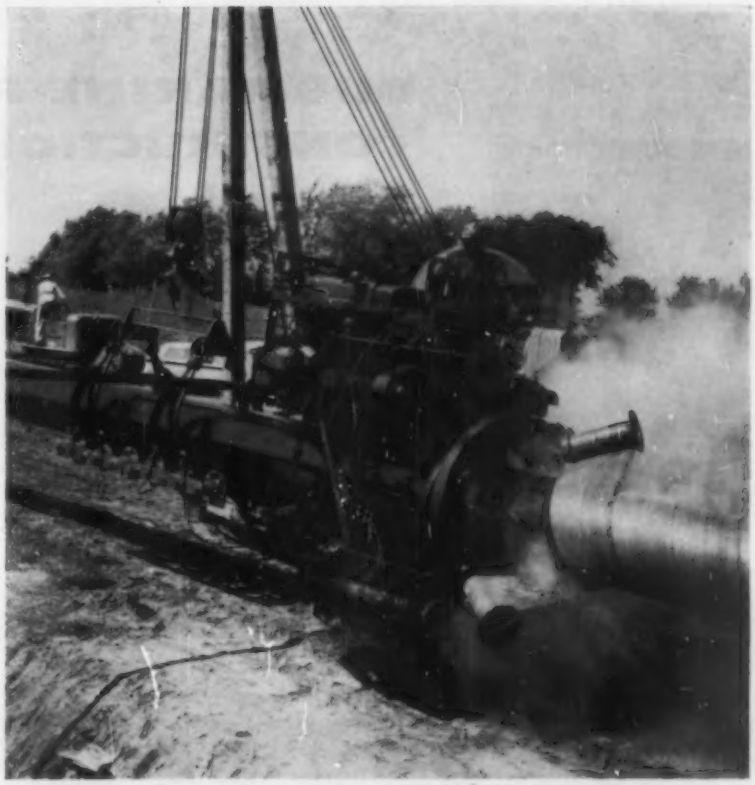
The line, built to operate at 880-psi pressure, was tested at pressures up to 110% of capacity.

Two Compressor Stations

Both of the pipeline's compressor stations each have a total of 5100 hp in gas-driven centrifugal compressor engines, with three 1700-hp units at each location.

Through purchase of six additional plots of land, provision has been made for future expansion of the system's compressor capacity. Suction and discharge valves were installed at each of these possible future compressor station locations.

Midwestern also operates a 350-mile, 30-in. pipeline from Portland, Tennessee, to Joliet, Illinois. Its gas is obtained from the parent firm, Tennessee Gas, and is delivered to three large Chicago-Gary area utilities. * * *



A part of the line was coated externally with an elevated-temperature coal-tar enamel and given an outer wrap of glass.

Petroleum wax covered by a 20-mil plastic wrapper and an 80-lb kraft paper wrap was used on 118 miles of the new pipeline.

SUBMARINE PIPELINE CONSTRUCTION METHODS

PART 1. Basic problems are: Economics, hydrologic and meterologic effects, bottom conditions, marine traffic, and properties of the pipeline itself . . . Here are the solutions

SEVERAL BASIC PROBLEMS are encountered in the design, construction, and operation of submarine pipelines. The problems are not unique to the owner, or to the design engineers, or to the contractor — they are common to all.

What are these problems and what are their effects on submarine pipelining? The following discussion points tnem out and gives one contractor's solutions.

Six basic problems are present in considering any submarine pipeline

JOHN G. BOMBA, *Civil Engineer, Collins Construction Company*

FIG. 1. Playa del Rey beach used for pipe make-up during installation of 36,772 ft long, 22-in. diam, sludge discharge line to serve the Hyperion Sewage Treatment Plant, City of Los Angeles, California.

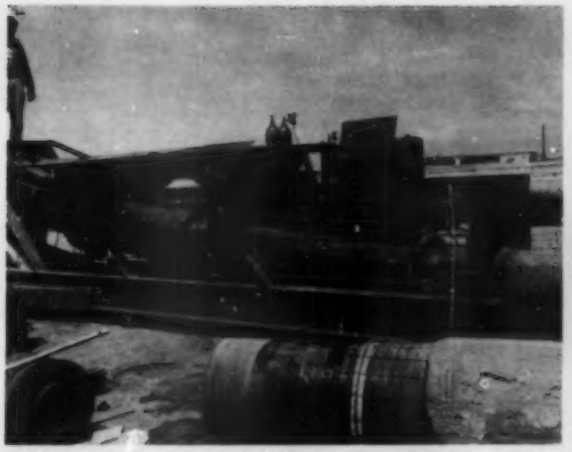


FIG. 2. Structural details of the pulling sled. The pulling force applied to the sled was transformed from a compressive load on the concrete to tension on the pipeline by means of the three rings shown welded to the pipe.

FIG. 3. Pontoon rigging being completed on the pulling sled. The pull bridle passed through the sheave attached to the forward end of the sled.

installation. Broadly stated, they are: Economics, hydrologic effects, meterologic effects, bottom conditions, marine traffic, and the properties of the pipeline itself.

Collins Construction Company has long recognized these problems and developing special methods and equipment to eliminate or minimize their effects on pipelines during and after construction is our business.

The construction projects to be described are practical applications of three of Collins' installation methods.

Ocean Outfall Line

Seven miles out in the Pacific, off the shoreline of Manhattan Beach, California, below 310 ft of water, lies the seaward end of the longest and deepest sludge discharge line ever installed (See Fig. 1).

Bid documents for the sludge discharge line contained two alternates. One specified reinforced concrete pipe with corrosion protection and concrete coating.

The construction contract for the steel pipe alternate was awarded on a low bid basis to Healy-Tibbets Construction Company, San Francisco, California; Submarine Pipeline Construction Company, Inc., Port Lavaca, Texas, a Collins affiliate; and the De-Long Corporation, New York, New York.

This outfall line was designed for a minimum life of 100 years by Hyperion Engineers, a joint-venture of the engineering firms of Holmes and Narver, the sponsors: Daniel, Mann, Johnson and Mendenhall; and Koebig and Koebig, all of Los Angeles, California.

The pipe is API 5LX-52, lined internally for uniform flow characteristics and protection from internal corrosion. Externally, the pipe has a triple-coat of glass-fiber-reinforced enamel and a final wrap of enamel-impregnated pipeline felt. A 1½-in. thick concrete jacket, reinforced with 2-in. by 4-in. 12-gage, crimped galvanized wire mesh was applied to give the completed line a negative buoyancy of 4 lb per lineal ft when empty.

Hyperion Engineers required that the enamel coating be continuously monitored during pulling operations to determine immediately any holiday resulting during installation.

This requirement made it necessary to insulate the sludge line proper from any steel in contact with sea water. To do this, Collins' engineers designed a 60,000-lb gross weight, reinforced concrete and steel structure to transfer the pulling force to the pipe. Circular steel plates were welded to the pipe, and high early strength concrete was poured around the pipe and rings. The 28-day compressive strength of the concrete averaged approximately 7500 psi. Fig. 2 shows the arrangement of the steel used in the sled prior to concrete pouring.

Two pontoons, each with a net lifting capacity of 20,000 lb, were attached to the top of the structure. The buoyancy of these pontoons, combined with the buoyancy of the structure itself, reduced its weight to approximately 500 lb in water (Fig. 2 and 3).

Because of the roughness of the waters and the 310-ft depth at the seaward end of the pipeline, Collins chose to install the sludge line by pulling it along the bottom, employing their Friction Transposition Installation Method.

Before proceeding with the project description, an explanation of this installation method is in order.

As the name *Friction Transposition* implies, the friction, relative to the ocean floor, of a dead load is transposed into working energy, which is used as an aid to pulling long pipelines along the bottom.

This procedure is illustrated in Fig. 4. Close study of the illustration will show six basic parts. These are the end anchor, the friction transposition cable, a pulling barge, two cable spooling units, a pulling winch, and the pull cable or "bridle," which is attached to the nose of the pipe.

The end anchor is essentially a safety factor. Although it is designed for a holding power in excess of the maximum anticipated pulling load to be applied to the pipe, the friction of the cable ahead of the anchor is usually greater than the actual load or pulling force required to install the pipeline.

A dual cable system is laid by the pulling barge from the end anchor toward the shore, from which the pipe is pulled. Beginning at the inshore end of the cable system, a cable size is selected that will allow pulling of several complete strings before the load equals approximately 50% of the breaking strength of the cable. Size changes are made through special transition blocks. The exact location of these blocks is determined by the pipe string lengths to allow removal of the friction transposition cable, reeled in by the spooling units, during tie-ins onshore.

After the pulling barge has completed laying the friction transposition cable to a point near the beach, the pull bridle is spooled off the drum of the

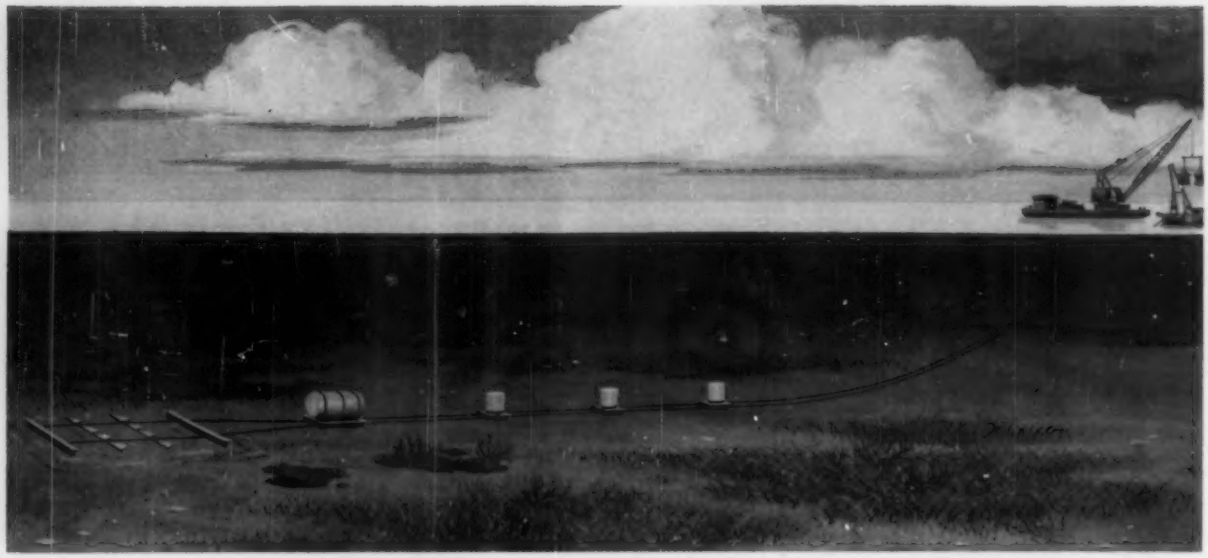


FIG. 4. The Friction Transposition Method as employed for the

pulling winch and taken ashore. There, the bight of the cable is placed around the sheave of the buoyant block. This block is pin-connected to the nose of the first string of pipe.

Pipe pulling is the reverse of cable laying. The pull barge takes in the pull bridle as the pipe moves into the water. While another string is tied into the pipeline onshore, the pulling barge moves back along the center line, picking up the friction transposition cable with the cable spooling units and relaying the pull bridle.

The spooling units are designed for a line pull only slightly greater than the weight of the largest cable to be retrieved and cannot take the pull load. Therefore, Carpenter Stops are used to transfer the pull force directly to the friction transposition cables, bypassing the spooling units.

After several pulls, the pulling barge will pick up the first transition block. The full cable reels are removed from the spooling units and two empty reels are set in place. The ends of the next cable are fastened to these empty reels and pulling operations are resumed.

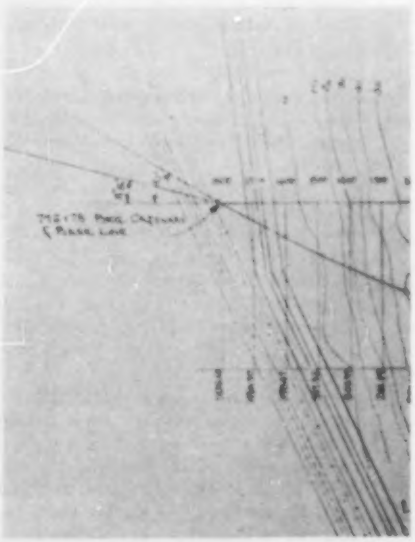
This procedure is followed for pulling the remaining strings of pipe in place.

On the Hyperion project, heavy surf and 6-ft tidal variations made it necessary to extend the launchway 900 ft offshore. A wooden trestle supported the pipe and launching units above the surf. This trestle is shown in the upper right corner of Fig. 1. A 4000 ft radius curve was built into the offshore end of the trestle to allow the pipe to enter the water immediately after leaving the last launching unit at any tide stage.

Because of the weight of the pulling sled, it was launched directly off the beach. Approximately 1000 ft of pipe was pulled with the sled for tie-in purposes. The tail-end of the pipe was pulled back onto the trestle and tied-in to the next section of pipe. Pulling operations were then started. These continued for seven days and seven nights with little interruption.

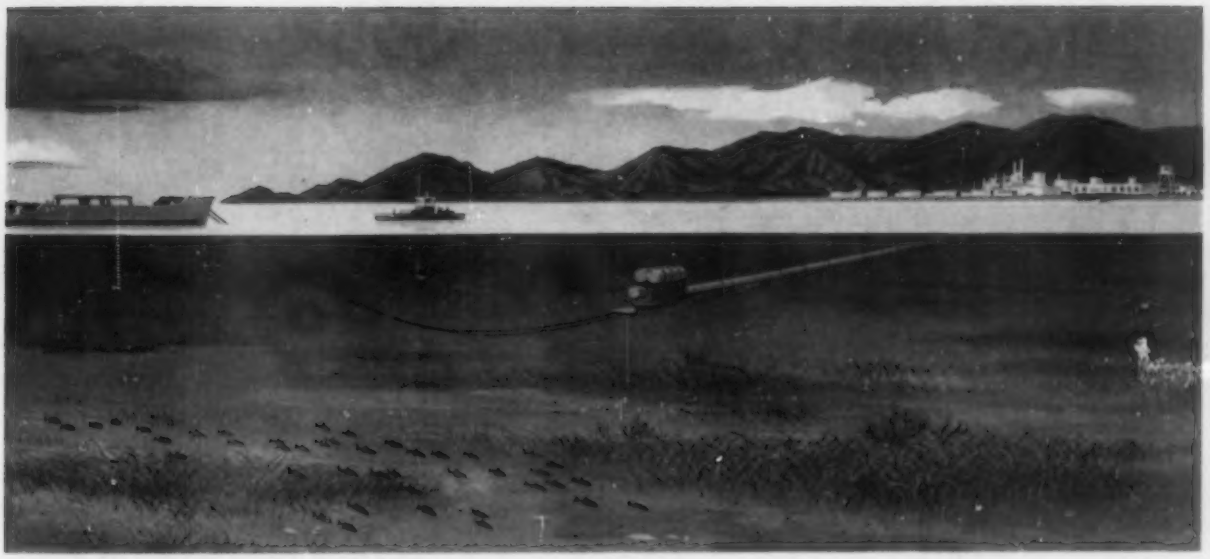
After completion of launching and testing operations, a Collins' patented Submarine Pipeline Jet Trencher was put on the line to bury 8000 ft of the line from the shore outward to provide additional protection against damage that might result from the heavy surf.

The Hyperion sludge discharge line was the first of several long pipelines installed by the Friction Transposition method. December, 1959, saw the completion of a 14-mile long, 30-in. diam, line from the mainland of Venezuela to the Island of Margarita in the Caribean Sea. This line, designed by Daniel, Mann, Johnson and Mendenhall de Venezuela, is a fresh water aqueduct and was designed for the



ABOUT THE AUTHOR

John G. Bomba is a civil engineer with Collins Construction Company, Port Lavaca, Texas. A 1954 graduate of Texas A&M with a BS degree in petroleum engineering with post-graduate work in civil engineering, he has five years' experience in the pipeline industry. He worked on his first submarine pipeline, the 1948 Alcoa gas gathering system in Matagorda Bay, between his junior and senior year in High School. He pioneered the use of the Tellurometer for offshore survey work, devising a measuring technique that was the basis of the instant plotting method currently used. He is a junior member of the Victoria, Texas, Chapter of the Texas Society of Professional Engineers.



installation of the Hyperion sludge discharge line.

same life span as the Hyperion line—100 years. Early in 1960, Collins, through its affiliate, International Marine Constructors, completed installations of the 100,600 ft long crude oil flow line from Kharg Island in the Persian Gulf to the mainland of Iran.

Pulling operations are presently underway on a dual 32-in. tanker loading line, 106,000 ft long, at Fao, Iraq.

Downstream Catenary

During its 1958 expansion program, Tennessee Gas Transmission Company was confronted with another Mississippi River Crossing, this one in the Delta country near Happy Jack, Louisiana. Well aware that the placid-looking waters of the Big Muddy can play havoc with an improperly designed and installed pipeline crossing, TGT planned accordingly.

As a result of the intensive surveys and careful study, an approximate catenary was calculated using the parametric form described by Tindall.[1]

This approximate catenary is shown superimposed on the bottom contour map of the crossing site in Fig. 5.

Collins Construction Company, who by this time had installed four catenary crossings of the Mississippi River for TGT, was awarded the installation contract.

The four lines previously installed were pulled into place using one crane barge for keeping the pull cable tangent to the design catenary at the leading or nose end of the pipe.

Evaluating the previous installations, Collins' engineers chose to modify the technique slightly to provide better physical control of the pipe during installation. One additional crane barge was located at the nose of the pipe to

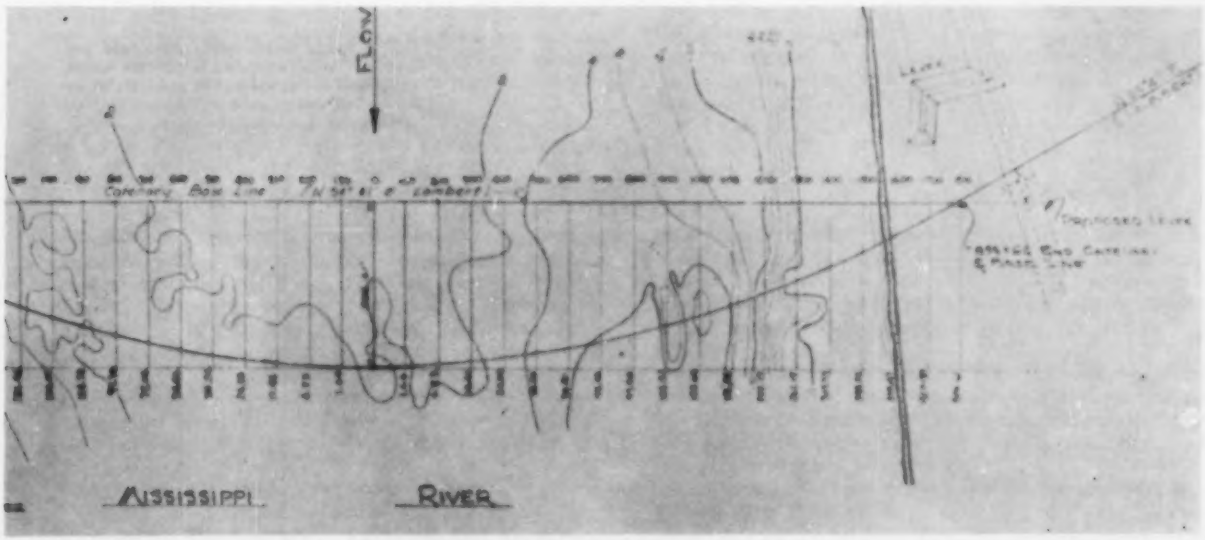
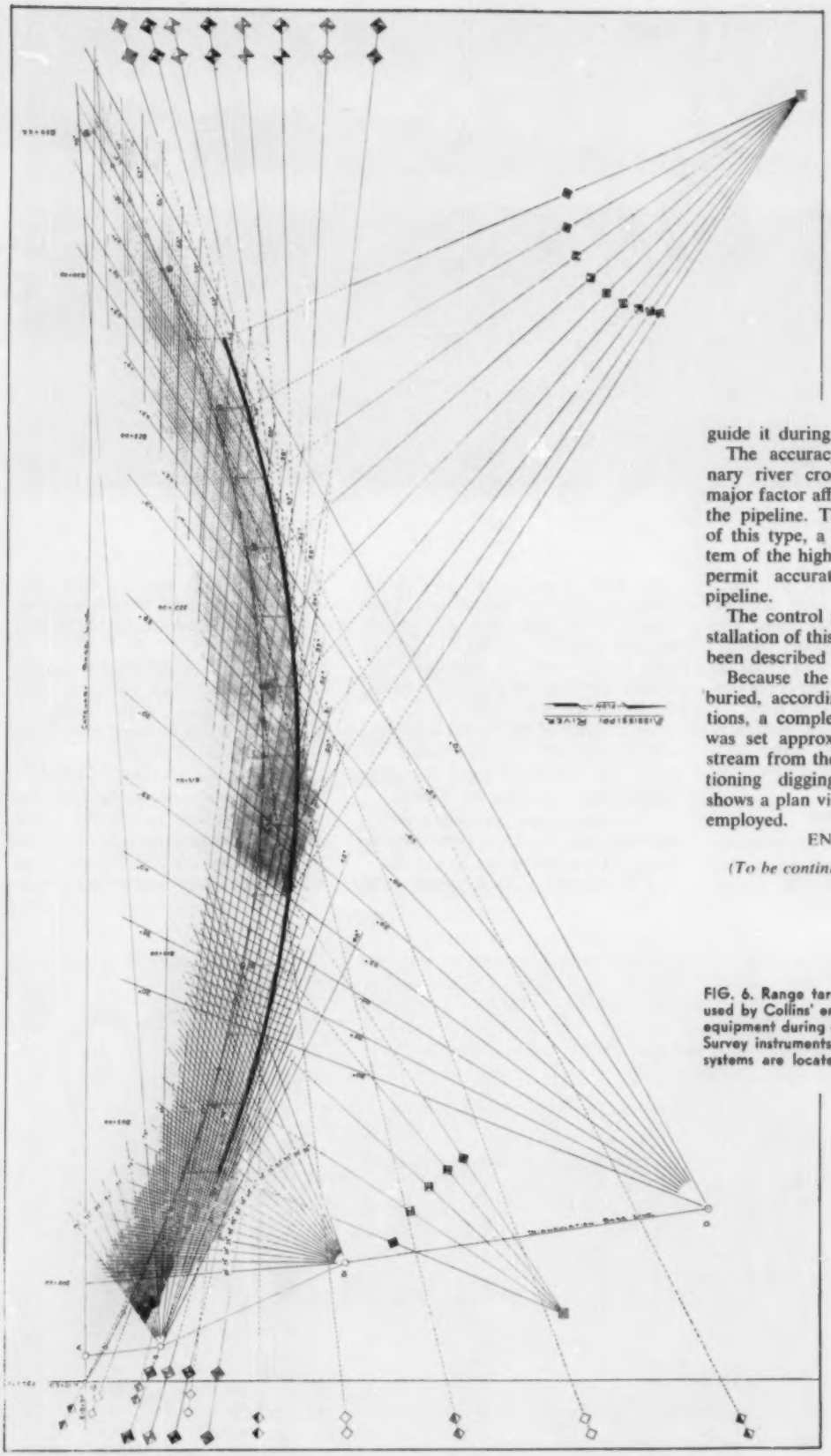


FIG. 5. Design catenary for TGT's "Happy Jack" Mississippi River crossing.



guide it during pulling operations.

The accuracy with which a catenary river crossing is installed is a major factor affecting the useful life of the pipeline. Throughout installations of this type, a horizontal control system of the highest order is required to permit accurate positioning of the pipeline.

The control system used during installation of this particular crossing has been described in detail by Brown.[2]

Because the pipeline had to be buried, according to TGT's specifications, a complete set of range targets was set approximately 100 ft downstream from the crossing site for positioning digging equipment. Fig. 6 shows a plan view of the range system employed.

END PART I

(To be continued in an early issue.)

FIG. 6. Range target system developed and used by Collins' engineers to position marine equipment during excavation and installation. Survey instruments used with instant plotting systems are located at Points A, B, and C.

Instrumentation, Controls, and Automation

Part 3: Telemetering

MAX T. NIGH

Noisy communication circuit on tone receivers

FIG. 9.

The pattern shown in Fig. 9 is a pattern that could be created by using the pushbutton we discussed in Fig. 8. It would be best reproduced by keeping time with jazzy music. Its randomness, however, is suggestive of some "unplanned-for" cause. It so happens this tone may be impressed on the voice channel from other sources than by energizing the tone transmitter. This noise can result from lightning, static electricity, dust storms, crosstalk from other strong signals on the communication system, and sometimes from use of test equipment on other channels.

Such a pattern of tone modulation will operate the receiving relay in the tone receiver at our unattended pipeline station and turn on the unattended machinery — "a very-much-to-be-avoided" situation.

The point we wish to emphasize is that more than one source of information is available to the tone receiver, and it has no ability to differentiate between (1) our pushing a button at a central point to energize a tone transmitter, and (2) noise.

A suggestion which would provide some security is to make the tone receiver delay starting the unattended machine until it has received a tone continuously for, say, 20 seconds. This adds some security, and although most noise bursts are of shorter duration, this does not prevent interference to the extent desired in pipeline systems where many stations are operating unattended.

This difficulty is overcome, to some extent, by using FSK (Frequency Shift) tone equipment as opposed to the economical AM (Amplitude Modulation) tone equipment; but this still does not destroy the basic ill. However, where few units are to be operated unattended, this method has received some use.

To start and stop unattended machines, however, was not the purpose of introducing this proposed method. It was suggested to permit you, the reader, to think about tone signals in a graphic manner and to recognize that the equipment we are using in automation today does not possess fine senses and a brain. What so-called "intelligence" today's equipment has is only what we can build into it. The logical step for us now to make is into analog telemetering.

Time impulse analog telemetering

Analog telemetering is transmission of a proportional signal from one point to another and keeping the signal a proportional one at all times. The most common and economic telemetering system used in industry is the time impulse type. Here time is the variable used to maintain proportionality — the length of time that a tone is transmitted on the communication circuit is proportional to the measurement. We suggested in discussing the last figure that varying the length of time a tone is transmitted could be used to control machinery. We are now transmitting information of a different type. This is now "how much" information as opposed to yes and no type of information.

Fig. 10 shows typical equipment used for time impulse telemetering. The upper portion is a block diagram showing the tone and telemetering transmitters as well as tone and telemetering receivers. In the telemetering transmitter a cam is rotated at constant speed with one revolution representing one transmission cycle. A pointer is allowed to ride on this cam. The pointer is positioned by a bellows, with the bellows displacement being proportional to the pressure in the pipeline.

The proportional time that the pointer is rubbing on the cam is the length of time the contacts (pushbutton) are left open. When the pointer is off the cam, for the remainder of one revolution of the cam, the contacts are closed and the tone transmitter is turned on.

The tone receiver is alternately energized and de-energized during each transmission cycle. The telemeter receiver positions a pen on the chart proportional to the proportional time period the tone is received.

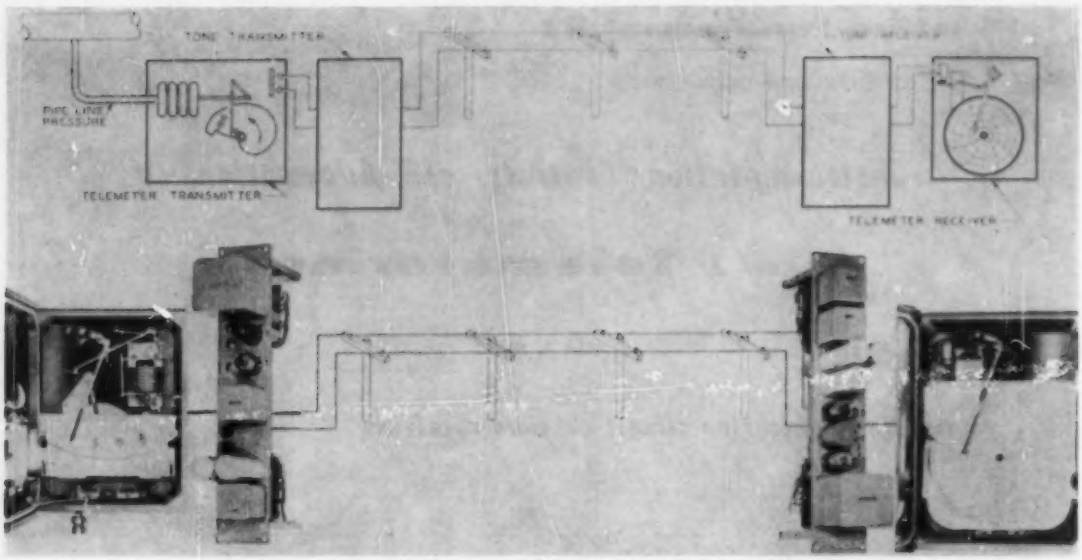


FIG. 10.

More specifically, the pen driving mechanism moves up scale from zero during the tone-on period and downscale starting at full scale during the tone-off period. If the reading is the same for each transmission cycle, the pen does not move.

If the tone is off for one complete transmission cycle, the pen is driven down scale to zero on the chart. If the tone is on for one complete cycle, the pen is driven upscale to full scale. The important concept is that the receiving pen is positioned proportional to the reception of a tone signal and has no direct connection to the measurement.

It is apparent that the receiver motor speed must be operating at the same or synchronous speed of the transmitting cam motor. To insure this, 60-cycle a-c power from commercial sources is ordinarily used. It is usually kept better than ±½ cycle. Cycle time of 2, 4, 10, 12, or 15 seconds are used with commercially available systems, with the most common being 15 seconds.

The lower portion of Fig. 10 shows the actual equipment used in a typical system for telemetering one measurement.

Time impulse pattern

Fig. 11 is a graphic representation of the time impulse pattern for the analog telemetering shown in Fig. 10. The tone transmitter would be turned on and off in a pattern as described above. Note that one cycle (one revolution of transmitter cam) is 15 seconds. The tone transmitter is turned on for a period proportional to the measurement (pressure, temperature, flow, etc.). Sometimes this pattern is referred to as pulse duration, time duration, or time modulation, since length of time of a tone transmission is the method used to convey information.

Three patterns are shown in Fig. 11, representing zero, 50% scale, and 100% scale readings of the measurement.

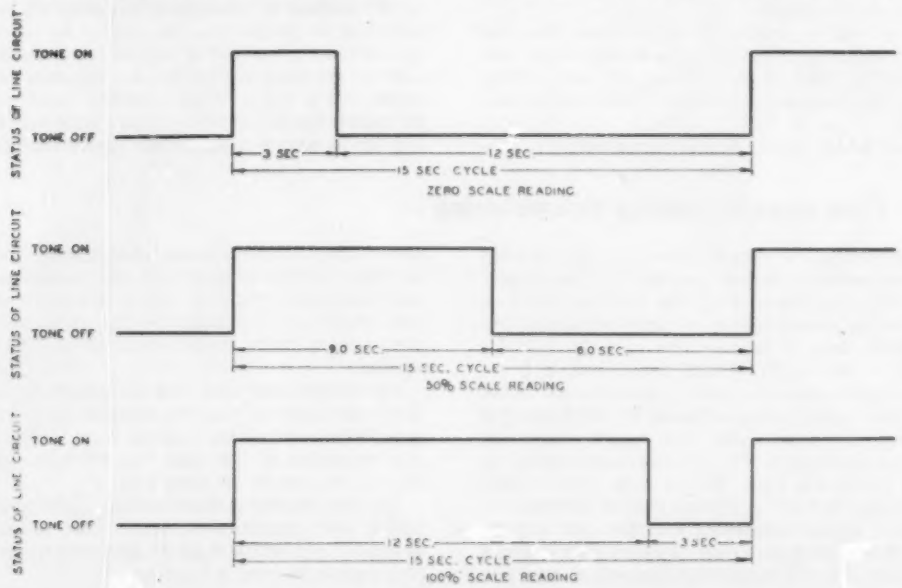


FIG. 11.

For zero scale reading, the tone is on for 3 seconds and off for 12 seconds for each transmission cycle. For a measurement of 50% of scale, the tone is on for 9 seconds and off for 6 seconds. For a measurement representing full scale, the tone is on for 12 seconds and off for 3 seconds.

It is apparent that the tone-off period is the complement of the tone-on period. Therefore, it is convenient to visualize information only being furnished by the tone-on period and no additional information being furnished by the tone-off period. Another conclusion, which will be valuable to us in future discussions is that the tone-off and tone-on positions could be interchanged, and we would still be transmitting the information satisfactorily. Quite pertinent to the case, of course, is keeping the method chosen the same at both transmitting and receiving ends. We may use mark-space to identify tone-on — tone-off, or two separate tones (frequency shift keying) or any two positions or levels that permit the separation and identification of two conditions. Mathematically this is simply a binary system. In computer logic we use "0" and "1" to designate these two conditions.

When we telemeter in missiles and rockets for the "space-age," the same concepts as discussed above are used for some systems. Of course, microseconds are the time periods involved instead of seconds, but the principle is the same. Variable frequency telemetering is another common type used in missile telemetering. This type is used to some extent industrially and will be discussed later.

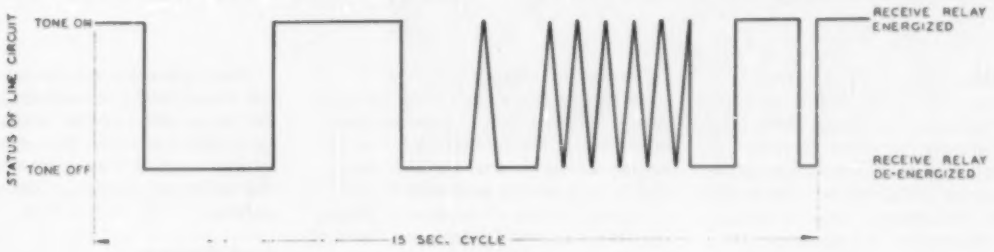


FIG. 12

Noisy telemetering channel

Fig. 12 shows a noise pattern that might result on a telemetering channel from interference caused by cross talk, lightning disturbances, or other noise sources on a communication system. The telemetering receiver would recognize this pattern as valid information, since it has no way of differentiating between noise and information in this case. In the system described in Fig. 10, the telemetering receiver would operate the pen-positioning mechanism to drive the pen up-scale during tone-on periods. To be correct, but not add any new concept, we can say: The pen position would change only if any continuous on or off time period exceeded the proportional position the pen was in at the start of each transmitted cycle.

Telemeter receiver record of noise

Fig. 13 shows a recording chart from a telemeter receiver. This is an actual recording of telephone line interference with pulse duration or time impulse telemetering. Note the pen was driven up scale as well as down scale. This indicates there were periods when the tone was not on the line at all during each cycle of transmission as well as periods when the tone was impressed on the telephone line for a period longer than the tone was meant to be present, as indicated by the proportional measurement pen position.

This example is given to demonstrate the point that the telemeter receiver is not measuring pressure, flow, or temperature, but rather is measuring a pulse length represented by the time a tone is present on the communication channel.

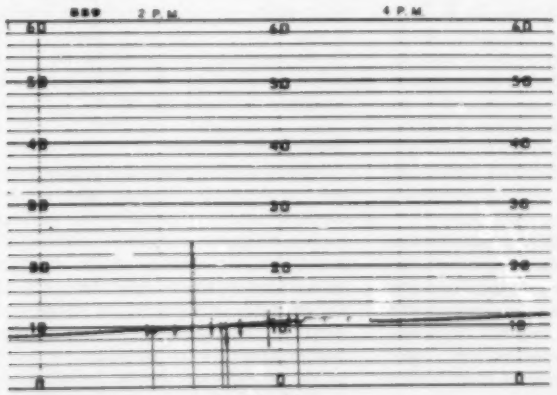


FIG. 13.

It must be recognized that this condition can be created from a number of sources, one of which is the telemeter transmitter-tone transmitter combination.

Interference of noise, etc., described above, is not a common occurrence on a well-designed and maintained communication system. However, it does happen at times on any communication system. The important facts to appreciate from this discussion are:

1. The telemeter receiver is not measuring directly the quantity it represents.
2. In pulse duration analog telemetering, there is no practical means for validating the reading as being the correct reading, in terms of automatic machinery.

What is Security of Data?

The principle reason we cannot check the validity of the analog signal before recording it is because it is a proportional type signal with the length of pulse equivalent to the measurement. In a sense, we check it by repeatedly sending the signal. As the measured quantity does not change rapidly, we can obtain a number of transmission cycles before any change occurs and this generally satisfies the reader of the receiver reading as being valid. This is not the most desirable way for a machine to be satisfied that the readings are correct. A digital telemetering system does provide the opportunity to make validity checks easily and economically. This is one of the prominent reasons for digital systems being so widely used today.

The validation of information (showing it to be the same at the receiving end as that transmitted) is described by the term "security." ★ ★ ★

EQUIPMENT MAINTENANCE
. . . one of a series

Whether Using or Storing . . .

WINTER CARE IS

REGARDLESS OF WHETHER you plan to use it or put it in storage until next spring, your equipment needs special care during the winter months.

Cold weather conditions create additional service problems for almost all types of equipment, and a sound winter productive maintenance program has to be well planned to allow for these problems.

Caterpillar Tractor Company reports there are five general areas that require extra special consideration for winter operations — lubrication, cooling system, starting system, fuel system, and electrical system. These same areas must also be cared for if storage is planned.

Lubrication

As temperatures settle to the lower ranges, lighter weight oils must be used. At below freezing temperatures, the engine crankcase should be filled with SAE No. 10 crankcase oils. The lower viscosity oil permits easier cranking of the engine and is fluid enough to circulate freely during the warm-up period.

During periods of extremely cold weather, or in climates of constantly very low temperatures, it may be necessary to dilute the oil with kerosine in order to provide sufficient viscosity. When temperatures rise somewhat, however, the diluted oil should be drained and the crankcase refilled with undiluted oil, as too-thin oil will not give proper lubrication in warmer weather.

Lubricant used for bearings must also be changed to a lighter grade for cold weather, with No. 1 or No. 0 normally the most successful.

A grade of at least No. 80 transmission oil is recommended by Caterpillar when temperatures drop below freezing. As with the crankcase oils, it may be necessary to thin this oil with kerosine during extremely cold weather periods. Again, however, the oil should be changed when warmer temperatures return.

Although of great importance during warm months, lubrication of the track and carrier rollers becomes even more important in cold weather operations. Except for the lifetime lubricated rollers, which require no field lubrication, it is generally necessary to switch to lighter grades of lubricants during sub-zero weather. In some instances it may be necessary to use oils in place of grease.

The ability of the standard grease gun to handle the grease outdoors is a good general guide as to when it is time to change to lighter grades, or switch to a crankcase or transmission-type lube oil. Track-type tractors equipped with lifetime lubricated rollers or idlers in good condition do not require refilling even in the coldest weather because they are filled with a low viscosity lubricant during factory assembly. They are refilled only at the time of rebuilding.

Starting

For machines equipped with gasoline starting engines, cold weather starting normally presents little difficulty, *if* both the gasoline and diesel engine are in good shape and the necessary precautions regarding lubricants have been observed.

Diesel engines depending on either electric or air starting systems, however, are sometimes difficult to start without some additional help in temperatures generally below 50 F. The solution in these instances generally is to use additional external heat, such as a manifold air heater or ether starting aids. In extreme situations, such as Arctic conditions, it often becomes necessary to heat the crankcase with a torch or some other form of high heat.

Cooling System

The onset of cold weather makes one think immediately of putting antifreeze solutions in his auto. The same care applies to construction equipment engines. With diesel engines, it is advisable to use permanent-type antifreeze solutions because of their higher operating temperatures.

Although some operators prefer to use water only as a coolant and drain the block and radiator at the end of each day, it is a risky business. Failure to drain out the water just one time can result in expensive damage to the engine.

Fuel System

While considering the possible damage caused by water freezing in a diesel engine, it should be kept in mind that the fuel system also can turn up trouble because of water. The best means of keeping water out of the fuel system is to prevent condensation inside the fuel tank. This is possible by filling the tank completely at the end of the workday. This pushes out the moisture-laden air. Also, much of the water that still gets into the system can be gotten rid of by draining off a small amount of fuel each morning. The fuel filter housing of Caterpillar diesel engines has a sump that traps any remaining water carried in the fuel. During cold weather the fuel filter housing should be drained at regular, short intervals to prevent accumulated water from freezing and possibly cracking the housing.

Other points to be considered for cold weather operation are: The type of fuel used, the general condition of the electrical system, and the care given the battery. For sub-zero operation, a fuel having an unusually low pour point should be used to insure proper flow of fuel from the tank to the fuel transfer pump. These are often called "winter grade" fuels and are available in most cold areas.

Electrical System

Before cold weather has arrived, the entire electrical system should be checked over . . . especially the starting engine magneto. For units fitted with direct electric starting only, particular attention should also be given to the battery. This should be tested frequently and charged whenever the charge drops below standard in order to insure sufficient power for starting. A discharged battery should never be

NEEDED

exposed to freezing temperatures as the electrolyte can easily freeze, causing the battery case to break.

A strong battery is especially important in cold weather because a battery's "cranking ability" drops quickly in cold weather and at the same time, the "drag" or inherent engine resistance increases rapidly. This means the battery has less energy to do a more difficult job.

Air Cleaner

Oil bath type air cleaners should receive even more careful attention during cold weather. As temperatures drop, oil in the air cleaner cup may have to be changed to SAE 10 weight in order to be carried up into the screens. If the oil does not reach and coat the screens, the efficiency of the cleaner drops considerably.

When equipment is operated in blowing snow, the air cleaner should be checked frequently because the cleaner or its inlet may be plugged quickly.

Dry type air cleaners require no special attention in winter operation other than frequent checks against plugged inlets.

Snow and cold weather conditions take an extra toll on equipment, making a sound winter maintenance program imperative.

Equipment must be in top shape to handle large diameter pipe under adverse conditions such as shown here.

Equipment Storage

The great danger to guard against in storing equipment is rust, both internal and external. Preventing its formation is of the greatest importance.

Equipment to go into storage should be first thoroughly lubricated, then completely washed, followed by spot painting of exposed metal surfaces. Bulldozer blades, cutting edges, moldboards, and other external surfaces not repainted should be coated lightly with grease to protect them from rust and corrosion.

The cooling system should be protected by filling with a permanent antifreeze solution that contains a rust inhibitor. If the engine is to be stored with a drained cooling system, however, a soluble oil type rust inhibitor should be added to the coolant during the last week of operation. This allows a film of oil to spread throughout the inner surfaces of the cooling system and provides a coating against rust.

If possible, however, it is best to store machines with permanent-type anti-freeze so that the engine can be turned over at weekly intervals without requiring special preparations.

Crankcases, transmission cases, and final drives should be cleaned, flushed and refilled with new oil before storing machines for the winter.

If possible, machines should be started once each week and the engine allowed to run several minutes. Also, on track-type tractors, it is advisable to run the machine forward and backward several times in order to redistribute the oil in the transmission and final drives, recoating all interior parts.

Under circumstances where it is not possible to operate the engine or machine on a weekly basis, it is advisable to add a cupful of oil in the top of each cylinder (less for small tractors and engines).

Rubber-tired units should be blocked up, if possible. If blocking is not practical, it is important to be sure that proper pressure is maintained throughout the storage period.

Above all else, however, before preparing equipment for winter storage, it is essential to read the operator's handbook for each machine involved. Much greater detail is offered in these booklets than is possible in this space. Proper precautions taken before the dead of winter arrives will assure each owner that his machines will be ready for operation when the full work season next gets underway. ★ ★ ★

Pipeline Projects

Fifth Firm Enters Race To Pipe Alberta LPG

Hudson's Bay Oil and Gas Company, Ltd. has filed an application with the Alberta conservation board for permission to construct a $1,700,000 pipeline designed to deliver into the United States, through the recently-authorized Glacier pipeline system, as much as 32,600 bbl per day of unrefined condensate.

The 41-mile, Canadian line would include 11 miles of 4-in. from Waterton Park and Castle River gas fields, through Pincher Creek gas field, from which 30 miles of 8-in. would run southeasterly to the international boundary at Carway, Alberta. If Canadian authorities grant an export permit, deliveries—expected to be initially from 4000 to 8000 bbl per day—will be made into the 433-mile Glacier system of the parent company of Hudson's Bay, Continental Oil Company. This system is designed for crude transport from Cut Bank, Montana, to the Platte pipeline terminus near Powell, Wyoming.

L. F. McCollum, Continental president, said that his firm would welcome the opportunity to market Canadian condensate in the northern states.

Hudson's Bay is planning the incorporation of a new subsidiary, Aurora Pipe Line Company, to facilitate crossing of provincial and international boundaries.

French Continue Tests For Sea Crossing

Technical problems of laying an underwater gas pipeline from the Algerian coast to Spain can be considered as solved, says the French Minister of Commerce and Industry, although profitability of the line to export Hassi R'Mel gas to Europe, and consent of Spain for its passage, remain to be worked out.

Gaz de France, with the assistance of the French Navy, began trial immersions of a new type of steel pipe last May. First trials were in shallow water with 8-in. pipe about 6/10 of a mile in length. Since mid-August the trials have been with the same diameter pipe almost two miles long and a depth of about 1968 ft.

Further trials at greater depths will be carried on in the next few months, according to the announcement.

The underwater pipeline, if decided upon, would be about 124 miles long and lie in depths of up to 8858 ft. This evidently refers to the much-discussed route from Arzew on the Algerian coast to Cartagena on the Spanish coast. It would be 11.8 in. in diameter and consist of four parallel lines, together capable of carrying 353,100,000 Mcf of gas annually.

Wyoming Lines Proposed

Two new pipelines in Wyoming have been proposed to connect with the existing Service Pipe Line Company system.

El Paso Products Pipeline Company will construct a 32-mile, 6-in. crude line from Patrick Draw field in Sweetwater County to a connection with Service pipeline near Wamsutter.

The Teton Pipeline Corporation has filed an application with the state's Public Service Commission to build a 67-mile, 6 or 8-in. crude line from Barber Creek and Dead Horse Creek fields to terminal facilities in Salt Creek field and a connection with Service at Midwest.

Texas Gas Plans Additional 146 Miles

Texas Gas Transmission Corporation has proposed in a new application filed with the Federal Power Commission $16,800,000 in construction that would extend its supply lines farther into the prolific South Louisiana producing area.

The construction is planned in 1961 to make an additional 50,200,000 cu ft of gas available daily to 41 customers in Arkansas, Mississippi, Tennessee, Kentucky, Illinois, Indiana, and Ohio.

Loop lines, totaling 96 miles, would include 30-in. diam in various lengths up to 15 miles near Slaughters and Fulton, Kentucky; Friendship and Memphis, Tennessee; Lake Cormorant and Clarksdale, Mississippi; and Bastrop and Monroe, Louisiana; and 26-in. diam in lengths up to 15 miles near Hardinsburg, Kentucky; and Eunice and Lafayette, Louisiana; plus eight miles of 6-in. near Greencastle, Indiana.

A 50-mile, 8 and 16-in. line would be built to connect the Texas Gas system with five producing fields in Terrebonne Parish.

Plans Line For West Central Texas Gas

Latest phase of Lone Star Gas Company's activities in West Central Texas is the planned construction of a $2,000,000, 18-in., 52-mile natural gas pipeline that will increase capacity of the company's transmission facilities by more than 100,000,000 cu ft daily.

Although the project is subject to final approval by Lone Star's board of directors, preliminary engineering and surveys are now underway. Actual construction would begin early in 1961, according to Lone Star's president, L. T. Potter.

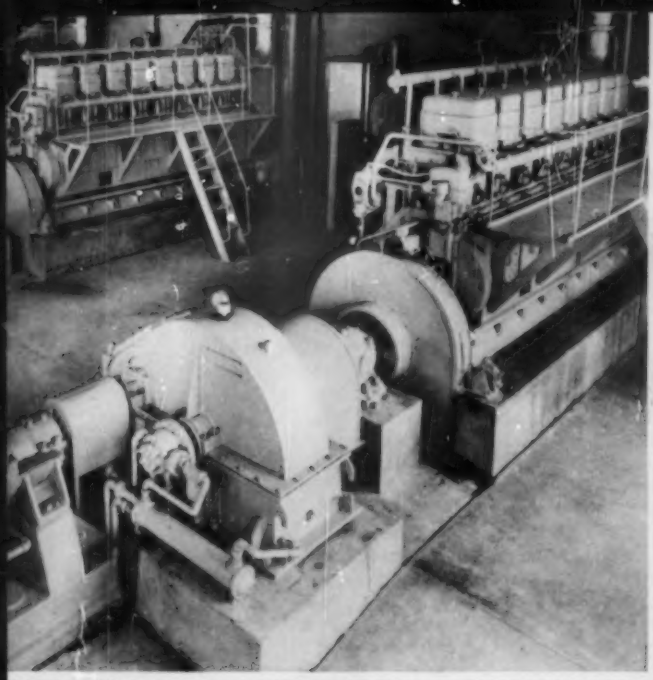
The pipeline would run in a southwesterly direction from the company's Springtown gasoline plant, across Parker and Palo Pinto counties, to Gordon in Palo Pinto County. At Gordon it would tie into the outlet of the company's Gordon gasoline plant and the east end of a recently-completed 12-in. transmission line that now terminates near the corner of Brown, Comanche, and Eastland counties. At Springtown the new 18-in. line would tie into a 48-mile, 20 and 24-in. line recently completed to the edge of northwest Dallas County.

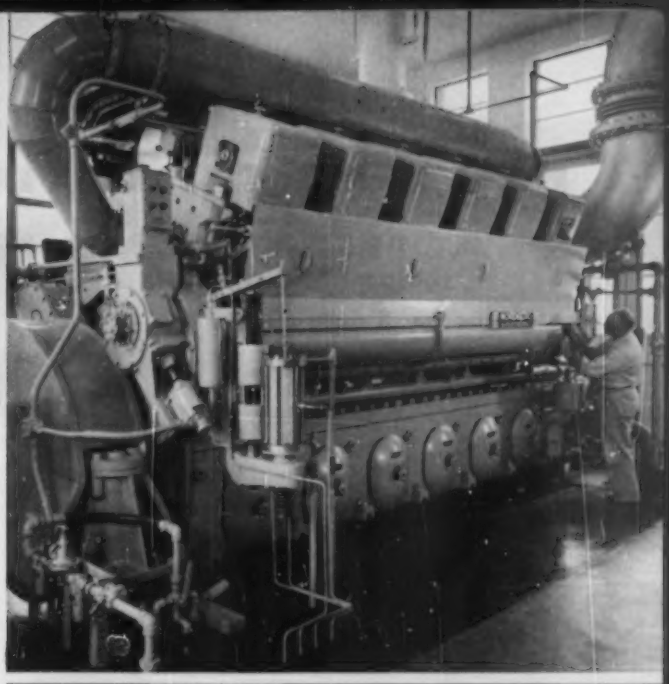
INTERNATIONALLY...

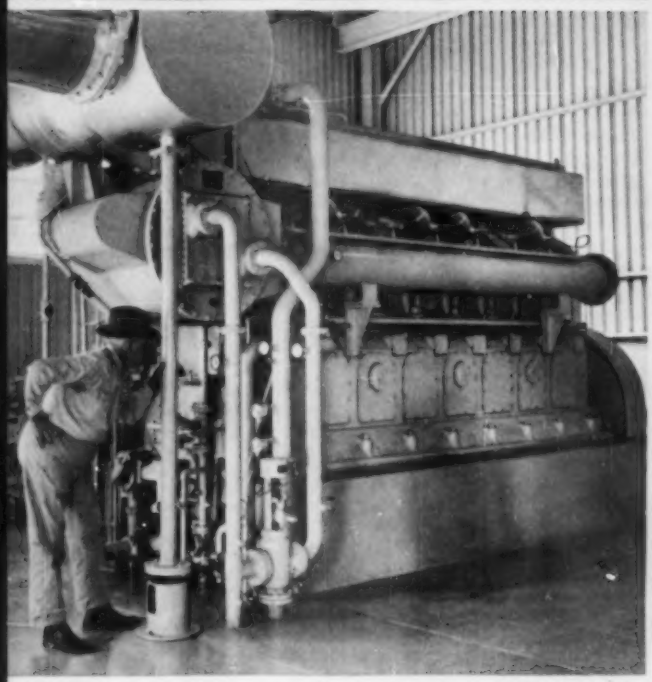
Qatar government has appointed Pencol of London as engineering consultants and designers for a gas pipeline system between Qatar Petroleum Company Ltd.'s oil field concession near Dukhan in the west and Doha, the capital in the east, where the gas will feed power stations, a water distillation plant, and other installations. The system, scheduled for completion by the end of March, will include about 50 miles of 10-in., and 10 miles of 6-in. with a dehydration plant at Dukhan.

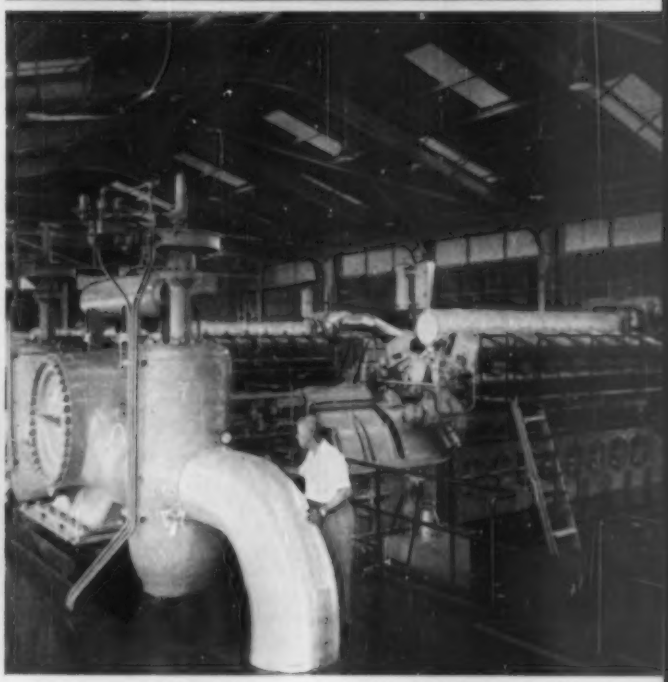
According to the Foreign Information Department of the Polish Press Agency, the Soviet Union has signed an agreement to supply Poland with 35 billion cu ft of gas a year by 1965. Involved will be construction of a pipeline from Western Ukraine to the Polish frontier near Przemysl, thence the refinery at Plock now under construction.

Oil India Private Limited's 720-mile, Nahorkatiya-to-Barauni crude oil pipeline will get telemetering facilities to ensure a constant check on its oil flow output. The transmission path will follow the oil pipeline route from the issuing station at Nahorkatiya, westward along the Brahmaputra Valley for 260 miles to the pipeline control headquarters and government oil refinery at Nunmati. It will then cross to the north side of the river and continue westward for an additional 460 miles ending at the terminal oil refinery at Barauni.









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FPC AUTHORIZATIONS REACH ALL-TIME HIGH

THE FEDERAL Power Commission authorized construction of $846,677,000 in new interstate natural gas transmission facilities, including nearly 9400 miles of pipeline, during the fiscal year ended June 30, 1960, FPC Chairman Jerome K. Kuykendall reports.

Both the cost and mileage are record annual highs for the 18-year period the commission has had jurisdiction over interstate pipeline construction. The authorized construction will add more than 10% to the total dollar investment in all interstate pipeline facilities approved by the FPC since 1942, when the present certificate provisions of the Natural Gas Act became effective.

Certificates issued during the 12-month period also authorized construction of approximately 403,000 hp in compressor units. The facilities are designed to add more than 3,250,000,000 cu ft daily to the delivery capacity of the nation's individual transmission systems, including some capacity to receive additional gas supplies into these systems.

Statistics include only facilities authorized for interstate pipeline companies and do not cover certificates issued to independent producers.

Major Projects

Major projects — those estimated to cost $700,000 or more each — accounted for nearly $805,600,000 of the total construction cost. These major projects will increase the daily delivery capacity of the individual systems by more than 3,270,000,000 cu ft of gas daily, including the capacity increases to receive additional gas supplies. They include more than 8700 miles of pipeline and nearly 402,000 hp in new compressor units.

Chairman Kuykendall's report estimates that 120 cities of 50,000 population or more in 19 states and the District of Columbia, as well as numerous smaller communities, will benefit from these larger projects.

The largest single certificate authorization during the 1960 fiscal year was issued to Transwestern Pipeline Company, of Houston, Texas, for a new Texas-to-California transmission system. This certificate, issued in August of 1959, authorized 1809 miles of 4 to 30-in. main, supply, and lateral lines, and 40,890 hp in compressor capacity. The project, estimated to cost nearly $192,000,000, connects southwestern gas reserves to the system for an initial delivery capacity of 350,000,000 cu ft per day for ultimate consumption in southern California.

The overall capacity increase of more than 3,250,000,000 cu ft to the nation's individual transmission systems represents only a slight gain over the preceding year when the total was less than 3¼ billion. Even so, Chairman Kuykendall said that the accelerated pace of activity during recent years does not reflect the full increase in available supply and transmission of natural gas to the nation's markets. He pointed to the increasing number of projects being authorized that involve the improvement and assurance of continuity of service through the acquisition of new additional gas reserves, the expansion of storage facilities, and the rearrangement and replacement of less efficient and antiquated facilities.

He said this is emphasized by the fact that a substantial majority of the 207 certificates authorizing construction in fiscal 1960 did not add to the main line daily delivery capacity or sales capacity of the various pipeline systems, but rather increased their ability to receive additional gas from producing areas, to inject or withdraw gas from storage fields near the market areas, or to deliver gas through sales laterals.

94,000 Miles Since '42

The report shows that since February 7, 1942, when the present certificate provisions of the Natural Gas Act became effective, the FPC has authorized construction of more than 94,000 miles of pipelines, over 6,438,000 hp in compressor units, and other related facilities, with a total estimated cost of approximately $8,058,000,000. Major projects authorized during this period were designed to add nearly 37 billion cu ft of daily delivery and supply capacity to the individual systems involved. The quantity of this gas delivered directly from transmission facilities to the nation's markets is actually somewhat lower because in some cases the gas is transported through facilities of two or more pipeline systems.

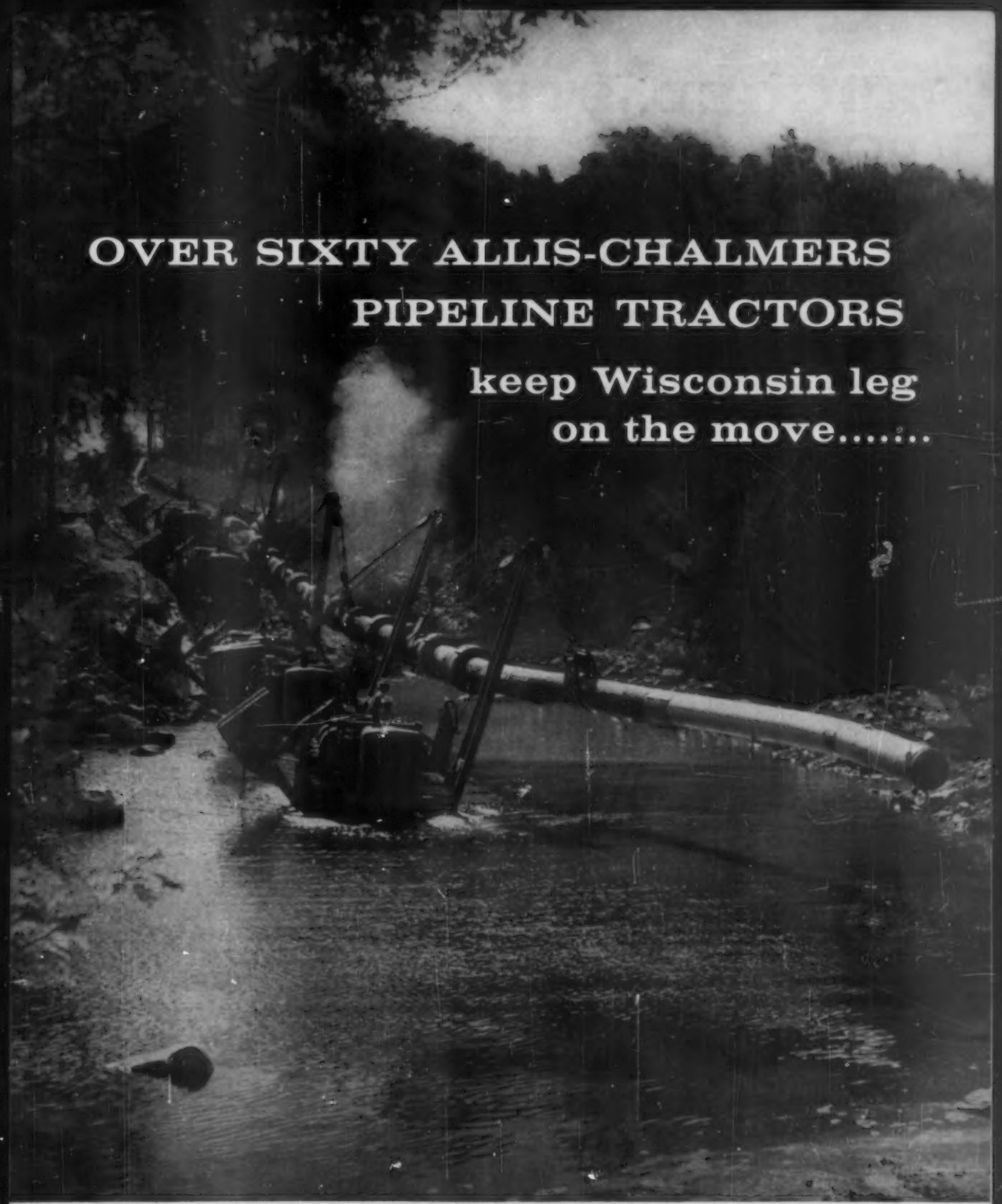
Chairman Kuykendall noted also that the continued development and operation of underground storage nearer the ultimate markets enable the pipeline companies more fully to utilize the maximum capacity of their transmission systems during the summer months. These storage operations, he said, by action to stabilize supply and insuring continuity of service are an increasingly important factor, particularly during extreme cold periods, but are not reflected as additional pipeline sales capacity made available to the nation's markets. * * *

Summary of Certificates Issued by the Federal Power Commission Between February 7, 1942, and June 30, 1960

Fiscal year ending June 30	Number of certificates	Total miles of lines	Total additional compressor horsepower (1000)	Estimated cost ($1000)
1942[1]	1	20	—	$ 87
1943	4	51	3.6	1,643
1944	25	2,373	108.5	106,082
1945	43	1,181	66.6	34,171
1946	52	2,994	184.3	127,190
1947	132	5,369	360.4	273,190
1948	98	8,468	371.3	519,946
1949	91	7,045	436.3	566,203
1950	108	6,188	493.3	487,240
1951	173	8,695	736.1	725,433
1952	136	3,378	539.5	321,920
1953	133	7,123	582.7	723,038
1954	165	6,405	251.5	500,881
1955	140	4,927	259.0	465,324
1956	164	4,357	254.9	461,413
1957	174	6,787	350.0	615,966
1958	337	4,372	423.7	518,822
1959	198	4,893	613.9	763,037
1960[2]	207	9,389	402.6	846,677

[1]From February 7, 1942

[2]During this 12-month period projects costing $700,000 or more each accounted for the following: Certificates — 74; miles — 8729; compressor horsepower — 401,500; estimated cost — $805,573,000



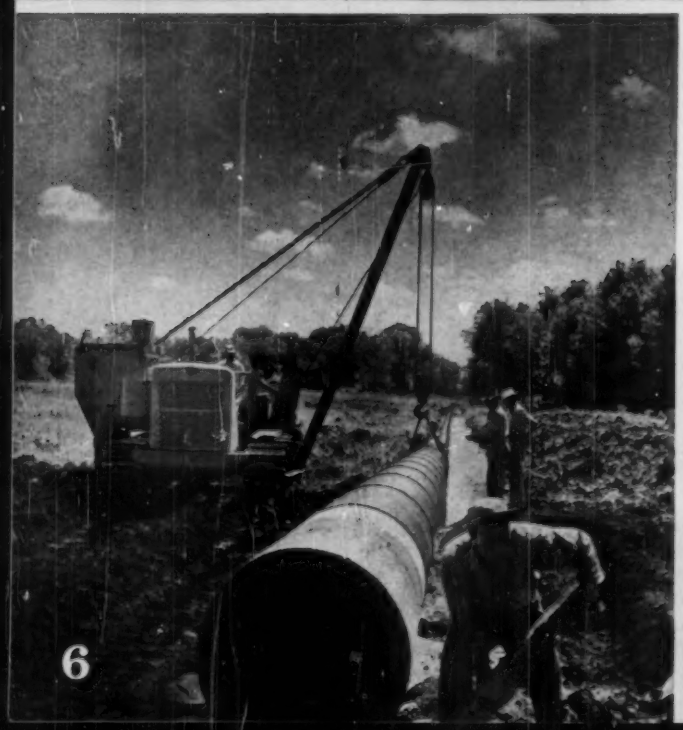
As a result of Canada's decision to allow natural gas exports into the United States, several multimillion-dollar pipelines will run from the Alberta gas fields to California, Minnesota, and Wisconsin. Panama, Inc., Houston, Texas, pipeline contractor, is working 66 miles of 24-inch Wisconsin mainline from Marshfield to Chippewa Falls. In this scene near Willard, Wisconsin, five of Panama's sure-footed Allis-Chalmers side boom tractors are walking a 90,000-lb length into the rocky Black River.

RUGGED, STEADY, POWERFUL PRODUCERS

maintain peak progress figures on every phase of the job

Over 60 Allis-Chalmers pipeline tractors are constructing a major part of nearly 500 miles of main and feeder lines in Wisconsin alone. More Allis-Chalmers tractors are swinging through Minnesota into Canada . . . pounding away at the $70 million, 893-mile system of natural gas pipelines from the Canadian border near Emerson, Manitoba, southeast to Appleton, Wisconsin.

Across streams and prairies, through swamps, beds of granite, trap rock and limestone, these tractors have veteran pipeliners agreeing heartily on one fact: "For cradling and towing, Allis-Chalmers pipeline tractors are the best in the business."



1. **Clearing Right-of-Way**—Working a 1,500-ft stretch at a time for Panama, Inc., this 150-hp torque converter-driven HD-16 averages about 5,000 ft of cleared r-o-w per day. Thick tangle is no match for this fast-acting, cable-controlled angle dozer for picking a path through rugged brush country.

2. **Pipe Stringing** — Service Pipe Line Stringing, Inc., is stringing 130 miles of feeder line from Stevens Point to Wausau, Wisconsin, for Panama-Williams. Jim Harrist says: "This HD-11 is a honey for stringing pipe. As a tow tractor, there's no place this machine says 'can't go' ... sometimes says 'almost can't' ... but never 'can't'."

3. **Dope-Wrapping** — Harbert Construction Company has 85 miles of 16-in. main feeder lines from Weyauwega to Marinette, plus 17 miles of off-shoot laterals. J. C. Ward, dope crew super, says: "HD-16's are the best machines built for cradling and towing. They're smooth ... keep everything moving at the right pace. Timing is the tough part of cradling — 16's make it a lot easier."

4. **Drilling River Bed Rock** — Panama, Inc. uses one of its 18 Allis-Chalmers tractors to help drill a river trench for blasting. Buck MacIntyre, spread boss, comments: "Allis-Chalmers has the best boom and tow tractors made. We haven't had a bit of trouble with our two-year-old boom spread ... haven't touched a final drive ... tracks have lasted 2-to-1 over any other."

5. **Making the Tie-in**—These 225-hp HD-21 side booms hold steady on the tie-in after gently lowering-in a 160-ft, heavily weighted section. As one operator puts it, "I know what's going to happen when I'm boomin' with an Allis-Chalmers ... and so do the guys on the ground. The boom controls are positive, handy and easy to work."

6. **Lowering-in**— One of Houston Contracting's HD-16 side boom tractors makes ready to lower-in and move ahead. Houston's 92 miles of 24-in. mainline between Appleton and Marshfield, Wisconsin, is a tough stretch with water-filled trenches and plenty of swamp. Good tractor flotation helps Houston's rapid progress.

7. **Backfilling**—Backfilling and cleanup operations along Panama, Inc.'s 66-mile mainline have to move fast to keep pace with the pipe-laying crew. Here, one of the five HD-16 torque converter dozers keeps the trench covered close behind the tie-in crew. This operator likes the speed and easy handling of the *16* ... says it will cover twice the trench of an ordinary dozer in the same amount of time.

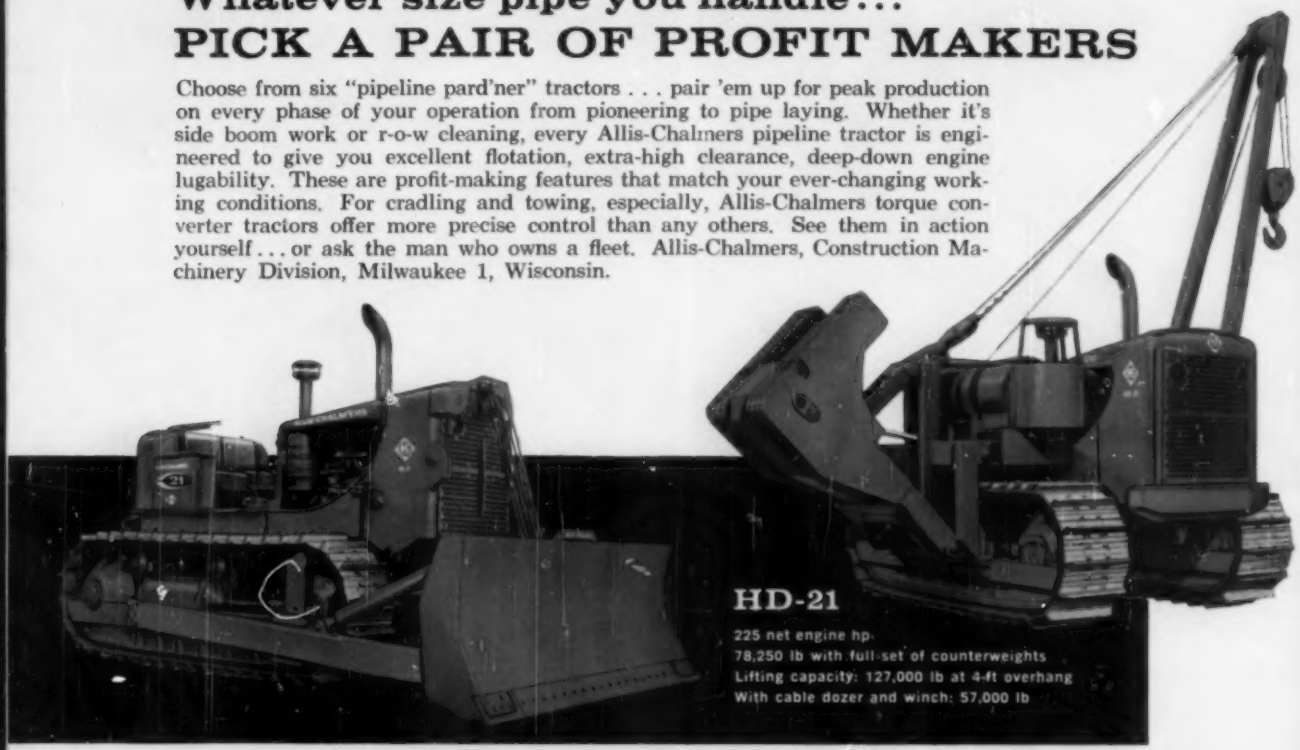
move ahead with **ALLIS-CHALMERS**

power for a growing world

Whatever size pipe you handle...

PICK A PAIR OF PROFIT MAKERS

Choose from six "pipeline pard'ner" tractors . . . pair 'em up for peak production on every phase of your operation from pioneering to pipe laying. Whether it's side boom work or r-o-w cleaning, every Allis-Chalmers pipeline tractor is engineered to give you excellent flotation, extra-high clearance, deep-down engine lugability. These are profit-making features that match your ever-changing working conditions. For cradling and towing, especially, Allis-Chalmers torque converter tractors offer more precise control than any others. See them in action yourself... or ask the man who owns a fleet. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

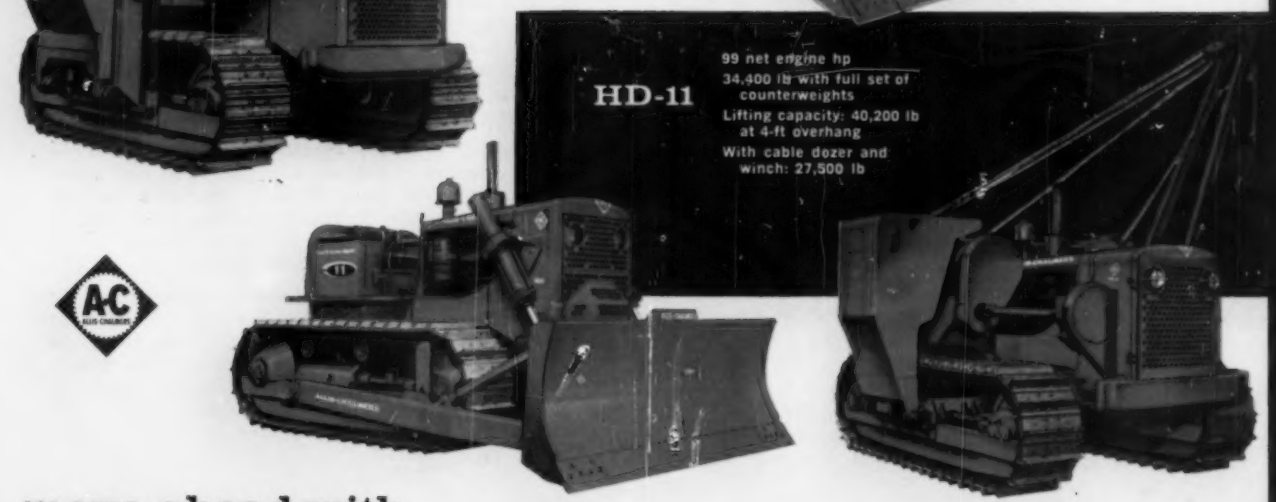


HD-21

225 net engine hp
78,250 lb with full-set of counterweights
Lifting capacity: 127,000 lb at 4-ft overhang
With cable dozer and winch: 57,000 lb

HD-16

150 net engine hp
59,010 lb with full set of counterweights
Lifting capacity: 78,000 lb at 4-ft overhang
With cable dozer and winch: 42,200 lb



HD-11

99 net engine hp
34,400 lb with full set of counterweights
Lifting capacity: 40,200 lb at 4-ft overhang
With cable dozer and winch: 27,500 lb

move ahead with

ALLIS-CHALMERS power for a growing world

FPC FILINGS

Recent Applications For Gas Line Construction

Colorado Interstate Gas Co., Colorado Springs, Colorado, Docket No. 138, filed week of November 4, 1960.

Description: Budget-type for construction of "routine pipelines, etc." Exact location and nature of proposed facilities unknown.

Cost: $800,000 total; individual items not to exceed $400,000.

Columbia Gulf Transmission Co., Houston, Texas, Docket No. 112, filed Oct. 6, 1960.

Description: Budget-type for facilities in 1961 to take into its main pipeline southern Louisiana gas.

Cost: $1,500,000 total; single project limitation, $500,000.

El Paso Natural Gas Co., El Paso, Texas, Docket No. 92, filed Sept. 26, 1960.

Distance: 8 miles.

Size: 4½ in.

Description: Construction and operation of facilities and delivery of gas to Northern Natural Gas Company at various points in Ochiltree County, Texas.

Cost: $15,000.

Docket No. 108, filed Oct. 5, 1960.

Description: Budget-type for facilities to provide services to customers. A total of 30 main line taps, with appurtenances, at various locations, 15 main line measuring and regulation stations; two lateral or branch pipelines 2½ and 6⅝ in. OD.

Cost: $800,500 total.

Michigan-Wisconsin Pipe Line Co., Detroit, Michigan, Docket No. 102, filed Sept. 30, 1960.

Distance: 62 miles.

Size: 20 in.

Distance: 35 miles.

Size: 16 in.

Description: Plus needed facilities, to purchase, receive, and transport natural gas from the Woodward, Oklahoma, area, to its main transmission line at compressor station No. 2, Kiowa City, Kansas.

Cost: $5,958,000 total.

Natural Gas Pipeline Company of America, Chicago, Illinois, Docket No. 120, filed Oct. 17, 1960.

Distance: 33 miles.

Size: 10 in.

Description: Lateral supply line extending from its 26-in. pipeline in Refugio, Texas, to the Normanna area near Beeville in Bee County, Texas, to facilitate purchase of natural gas from sources in the Normanna area.

Cost: $1,128,000.

Docket No. 129, filed week of Nov. 4, 1960.

Description: Budget-type for side taps on transmission system, meter stations, lateral branch lines in Texas, Arkansas, Missouri, Illinois, Iowa, Kansas, Oklahoma, and Nebraska, as needed and as follows: side taps—19 of 4 in. or equivalent; pipe—167 miles, 6⅝-in. OD or equivalent; meter facilities—29, 6-in. or equivalent.

Cost: $3,500,000 total; in any one producing area not to exceed $875,000.

Natural Gas Storage Co. of Illinois, Chicago, Illinois, Docket No. 97, filed Sept. 30, 1960.

Description: To construct and operate two Galesville Reservoir and five Mt. Simon reservoir injection withdrawal wells to increase maximum day withdrawal by 75,000 Mcf to a total of 725,000 Mcf. Location: Herscher storage field, Kankakee, Illinois. Includes about 6000 ft of 10-in. and 2000 ft of 18-in. gathering line at the proposed Galesville and Mt. Simon wells.

Cost: $1,850,000 total.

Northern Natural Gas Co., Omaha, Nebraska, Docket No. 132, filed week of Nov. 4, 1960.

Distance: 5.9 miles.

Size: 30 in.

Description: Loop north of Beaver compressor station between Hobbs, New Mexico, and Sunray, Texas, plus upgrading 26-in. line between Mullinville and Bushton compressor stations from 500 to 640 psi and interconnecting 30-in. at Bushton.

Cost: $1,232,200 total.

People's Gulf Coast Natural Gas Pipeline Co., Chicago, Illinois, Docket No. 96, filed Sept. 30, 1960.

Distance: 50 miles.

Size: 20 in.

Description: In Jim Wells County, Texas, near La Gloria.

Distance: 4.5 miles.

Size: 6 in.

Description: Lateral supply pipeline in Thompsonville and Taquachic Creek areas in Zapata, Jim Hogg, and Webb Counties.

Cost: $3,233,000 total.

Tennessee Gas Transmission Co., Houston, Texas, Docket No. 106, filed Oct. 4, 1960.

Description: Budget-type facilities necessary to receive deliveries into its system.

Cost: $5,000,000 total; single project limitation, $500,000.

Texas Eastern Transmission Corp., Shreveport, Louisiana, Docket No. 85, filed Sept. 23, 1960.

Description: Budget-type construction for 1961.

Cost: Not to exceed $4,000,000; single project limitation, $500,000.

Transcontinental Gas Pipe Line Corp., Houston, Texas, Docket No. 124, filed Oct. 24, 1960.

Distance: 14.84 miles.

Size: 36 in.

Description: Main line loop in North Carolina to bypass a reservoir of Duke Power Company now under construction on the Catawba River where water will flood the existing pipeline installation when the dam is closed and water is impounded. Work would have to be completed by December 1, 1961, to coincide with anticipated flooding after dam closure. The loop will extend from MP 1278.01 in Lincoln County, south through Mecklenburg County, to MP 1287.35, at compressor station No. 15 in Iredell County.

Cost: $2,546,073.

United Gas Pipe Line Co., Shreveport, Louisiana, Docket No. 131, filed week of Nov. 4, 1960.

Distance: 20.75 miles.

Size: 24 in.

Description: Loop to be constructed in 1961. Beginning near Milepost 56.7, Sec. 30, Township 1 North, Range 31 west, Escambia County, Florida, to Sec. 25, Township 3 South, Range 4 east, Baldwin County, Alabama.

Cost: $625,716.

Distance: 18.70 miles.

Size: 24 in.

Description: Loop to be constructed in 1962. Beginning at north terminal of above, extending to 16 by 20 in. swage near Milepost 17, Baldwin County, Alabama.

Cost: $532,315.

ALLIS-CHALMERS power for a growing world

WITH THE PIPELINE CONTRACTORS

● **Alberta Consolidated Pipe Line Builders.**
Alberta Gas Trunk Line Company, Ltd. —113 miles of 36-in. from Priddis, Alberta, to a point near Rocky Mountain House, and 64 miles of 16-in. from the main line near Waterton Park gas field to the Montana border near Carway. Alberta Consolidated is a joint venture of Mannix Company, Ltd., and Piggott Construction, Ltd., both of Calgary, Banister Construction Company, Ltd., Edmonton, and Marine Pipeline and Dredging, Ltd., Vancouver.

● **Banister Construction Co. Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta, Canada.**
Trans-Prairie Pipelines Ltd.—160-mile crude oil system in northeastern British Columbia, as follows: 40 miles of 4-in., Taylor to Dawson Creek; 30 miles of 6-in., Boundary Lake to Taylor; 75 miles of 8-in., Taylor to Milligan Creek field; 11 miles of 4-in., Milligan Creek to West Beaton field; 2 miles of 8-in., Taylor station to tank car loading rack; and 2 miles of 4-in., Taylor station to McMahon refinery. Martin Balaski is superintendent on the 4-in. line from Dawson Creek, where field office is located, to Taylor, and Ron Smith is office manager. Bill Bartlett is superintendent on the 6-in. Boundary Lake-to-Taylor line; field office is in Fort St. John; and Don Parker is office manager.

● **Basin Pipe Line Construction Co., Inc., Box 696, Tioga, North Dakota.**
Service Pipe Line Co.—a joint project with Oil Field Service Co., Inc., on 11 miles of 6-in. gathering arteries and 11½ miles of 2-in. lateral lines in Williams County, North Dakota.

● **Bechtel Corp., 220 Bush St., San Francisco 4, California.**
Michigan Wisconsin Pipe Line Co.—84 miles of 24-in. between the Mississippi River and Sandwich, Illinois; approximately 47 miles of 30-in. in Lake, Porter, and La Porte counties, Indiana; and approximately 14 miles in Berrien County, Michigan.
Esso Standard (Libya) Inc.—a 100-mile, 30-in. crude oil pipeline from the Zelten field in Libya, north to Marsa el Brega on the Gulf of Sirte.

● **D. Michael Curran & Co., Eklund Bldg., Great Falls, Montana.**
Great Northern Pipeline Co.—first section of proposed 110-mile, 6 and 10-in. crude line from Newburg, Wiley, and Glenburg pools of North Dakota to Minot.

● **A. J. Curtis & Co., 5105 N. Washington, Denver 16, Colorado.**
Garfield Gas Gathering — 29 miles of 10-in. in Colorado from Rifle to Rio Blanco, with H. W. Carey supervising at Rifle.
Western Slope Gas Co.—20 miles of 4-in. from Rifle to Powell Park, Colorado, 6 miles of 4-in. from Rifle southwest to Wells, and 6 miles of 6-in. from Palisades to Cameo. O. R. Avis is supervising at Rifle. Melvin Landes is general superintendent.

● **Dunn Bros., Inc., 805 Mercantile Securities Bldg., Dallas, Texas.**
Michigan-Wisconsin Pipe Line Co.—60 miles of 30-in. from St. John, Indiana, to Bridgman, Michigan, under the supervision of H. W. Gandy.
Texas Gas Transmission Corp.—56 miles of 12-in. in Indiana between Bedford and Coalmont, under the supervision of Alton Bean.

● **Dutton-Williams Brothers, Ltd., North Canadian Oil Building, Calgary, Canada.**
Alberta Gas Trunk Line Company, Ltd. —62 miles of 30-in. from West Cynthia to West Whitecourt, Alberta, and 20 miles of 22-in. lateral from this main line to the Whitecourt field.
Gas Trunk Line of British Columbia Ltd.—30 miles of 16-in. lateral from Boundary Lake gas field to Taylor processing plant.

● **Ford, Bacon & Davis Construction Corp., Box 1762, Monroe, Louisiana.**
Louisiana Gas Producing Co. — 25 miles of 8 to 18-in. Field office: Sterlington, Louisiana. Superintendent: F. A. Phillips.

● **R. H. Fulton & Co., Box 1526, Lubbock, Texas.**
Michigan-Wisconsin Pipe Line Co.—250-mile, 24-in. in Kansas, Missouri, Iowa. Also 24 miles of 6-in. near Sun Prairie, Wisconsin; and 9 miles of 6-in. and 17 miles of 8-in. near Manitowoc and Two Rivers, Wisconsin.

● **Groninger & King, Inc., Box 1381, Pampa, Texas.**
Northern Natural Gas Co.—15 miles of 26-in. from south of Spearman, Texas, to Spearman. W. G. Puckett is superintendent.

● **Harford Bros. Co., Box 191, Emporium, Pennsylvania.**
New York State Natural Gas Co. — a 13-mile welding job on 20-in. pipe with 1-in. wall thickness, near Tamarac, Pennsylvania, where field office is located. Whitey Martin is superintendent, and Monrowe Stevens welding superintendent. An undetermined amount of storage field pipe near Duboise, Pennsylvania, under the supervision of Elmer Landis.

● **Houston Contracting Co., 2807 Buffalo Speedway, Houston 6, Texas.**
Natural Gas Pipeline Co. of America—approximately 17 miles of 8-in. and 10 miles of 6-in. near Rockport, Texas, including a crossing of Copano Bay. A. J. Slovack is superintendent, L. L. Patterson is assistant superintendent, and Jack Hensley is field office manager at Rockport.
Transcontinental Gas Pipe Line Corp. —approximately 15 miles of 30-in. in the vicinity of Kay, Texas, and about 15 miles of 30-in. in the vicinity of Dayton, Texas, with M. L. Thompson as superintendent; and about 8 miles near Kinder, Louisiana, and approximately 7 miles near Mauriceville, Texas, with L. A. Young as superintendent.

● **M. L. Hulcher Co., Inc., Box 168, Virden, Illinois.**
Natural Gas Pipe Line Co. of America —two loop laterals to the town border stations for Princeton and Belvidere, Illinois.

● **C. S. LeNoir Construction Co., Box 798, Austin 64, Texas.**
Northern Natural Gas Co.—30 miles of 10-in. near Hutchinson, Minnesota.

● **Majestic Contractors Ltd., 49 Jackes Ave., Toronto 7, Ontario, Canada.**
Federated Pipe Lines Ltd.—14 miles of 6-in. and 19 miles of 6 through 8-in. crude oil pipeline in the Swan Hills area, Alberta, under the supervision of K. B. Killingsworth and Jeff Minter. Also, 41 miles of 16-in. from Oliver to Highbridge, Alberta, under the supervision of Jeff Minter at Morinville. Also, approximately 37 miles on 16-in. loops northwest of Edmonton.
Michigan-Wisconsin Pipe Line Co. — 60 miles of 30-in. near Joliet, Illinois, where R. L. Leonard is supervising.

● **Montin-Harbert Pipe Line Construction Co., Inc. 2808 First National Bldg., Oklahoma City, Oklahoma.**
Mustang Fuel Corp. — 155 miles of 12-in. natural gas pipeline system in central Oklahoma.

● **J. P. Neill and Company, Meadows Building, Dallas, Texas.**
Pacific Gas Transmission Company—468 miles of 36-in. from California-Oregon boundary to Rosalia, Washington, as joint venture with Western Pipeline, Inc., Austin, Texas.

● **Oil Field Service Co., Inc., Box 656, Tioga, North Dakota.**
Service Pipe Line Co.—a joint project with Basin Pipe Line Construction Company, Inc., on 11 miles of 6-in. gathering arteries and 11½ miles of 2-in. lateral lines in Williams County, North Dakota.

● **Panama, Inc., 1801 Tennessee Bldg., Houston 2, Texas.**
Continental Oil Co. — 8 miles of 24-in. and 65 miles of 16-in. beginning in Lake Charles, Louisiana, and extending to the Maurice-Milton areas in Vermilion Parish. Headquarters: Iowa, Louisiana. Superintendents: T. O. May and C. J. Hendrickson.

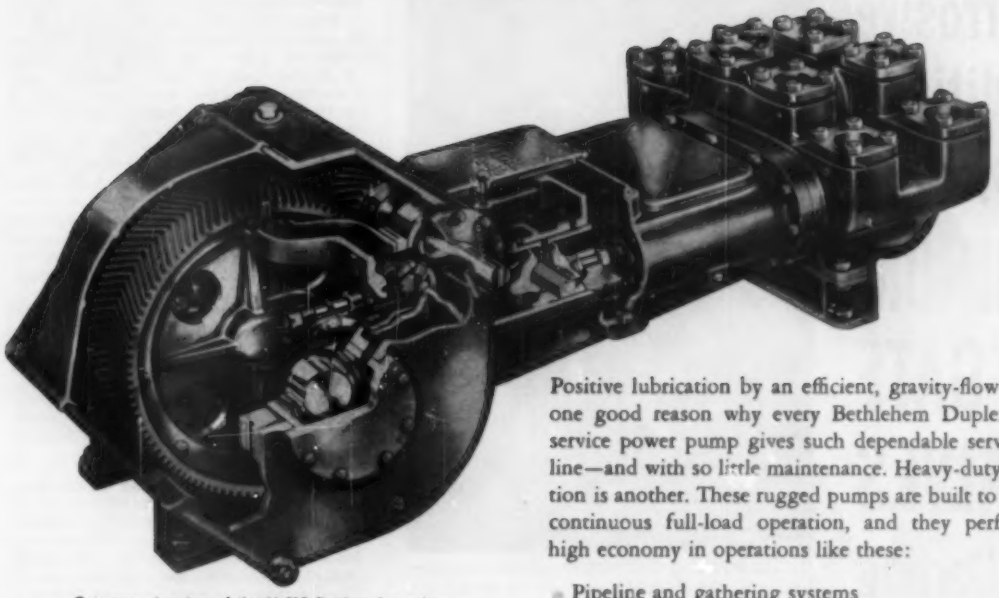
● **Panama-Williams Corp., 1418 Melrose Bldg., Houston, Texas.**
Peoples Gulf Coast Natural Gas Pipeline Co.—60 miles of 30-in. pipeline from Nacogdoches, where field office is located under the supervision of W. H. Shiflett, to Leggett, Texas.

● **H. C. Price Co., Price Tower, Bartlesville, Oklahoma.**
Peoples Gulf Coast Natural Gas Pipeline Co.—83 miles of 30-in. from Murphysboro, Illinois, to near Poplar Bluff, Missouri. W. H. Olrich is superintendent and A. P. Stotler is office manager at Jackson, Missouri.
Pacific Gas & Electric Co.—291 miles of 36-in. in California. Superintendent: R. L. Ezell. Office Manager: J. C. Eakin at Tulelake.
Pacific Gas Transmission Company—146 miles of 36-in. from Rosalia, Washington, to the Idaho-British Columbia border. Superintendent: G. A. Reutzel. Office manager: E. Dickson at Bonners Ferry, Idaho.

● **Price-Poole of Canada, Ltd., Calgary and Edmonton, Canada.**
Alberta Natural Gas Company — 107 miles of 36-in. from Crowsnest Pass to the Idaho boundary at Kingsgate-Eastport. Joint venture of H. C. Price Company of Canada, Ltd., Calgary, and Poole Construction Company, Ltd., Edmonton.

The Bethlehem Duplex

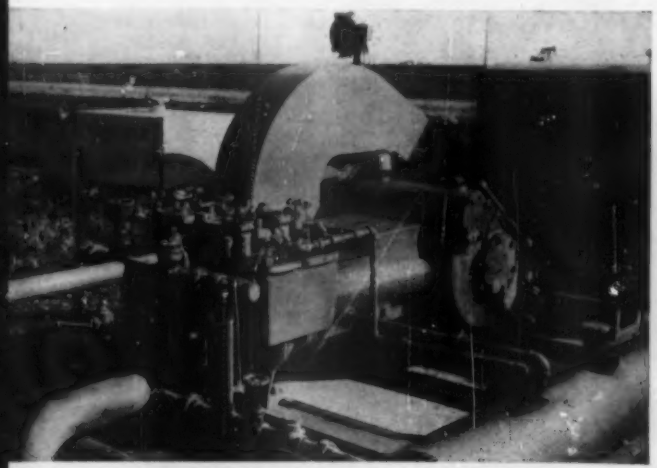
Keeps Oil On The Move



Cut-away drawing of the U-510 Duplex shows how lubricating oil, continuously collected from the gear rim, flows through the main and pinion bearings and into the oil chest, from where it is directed to the crossheads and to the crosshead-pin and connecting-rod bearings.

Positive lubrication by an efficient, gravity-flow system is one good reason why every Bethlehem Duplex general-service power pump gives such dependable service in the line—and with so little maintenance. Heavy-duty construction is another. These rugged pumps are built to run under continuous full-load operation, and they perform with high economy in operations like these:

- Pipeline and gathering systems
- Secondary recovery—disposal and supply systems
- Product, LPG, and oil-processing service
- Mud transfer and rig-water systems



On the job in a crude oil gathering system in West Texas, this Bethlehem UA-46 pump is good for many more barrels to come.

For the full story on the Bethlehem Duplex, write for our descriptive literature. Or inquire at our nearest office or store.

There's a size for every job. Choose between the U-33, UA-46, and U-510

Capacities: 155 to 13,500 BPD
Piston-Rod Loads: 2,400 to 12,000 lb
Pressures: 340 to 1,698 psi

For higher pressures, investigate Bethlehem's Triplex pumps, the TP-3, TP-4, and TP-6

Capacities: 100 to 11,700 BPD
Plunger Loads: 4,000 to 10,000 lb
Pressures: 566 to 5,000 psi

BETHLEHEM STEEL COMPANY
SUPPLY DIVISION
General Offices and Export Dept.: 21 East Second St., Tulsa, Okla.
Canadian Distributor: Bethlehem Supply Company of Canada, Ltd., Calgary, Alberta, Canada

BETHLEHEM STEEL · **SUPPLY DIVISION**

For severe corrosive conditions specify ALUMINUM GATE VALVES by Darling

Unique revolving disc feature assures maximum life under the most exacting service conditions. Friction between wedges is reduced to a minimum. Horizontal and vertical equalization of wedging pressure is assured.

Handling corrosive chemicals such as hydrogen peroxide, ammonium nitrate, acetic acid, concentrated nitric acid? Darling Aluminum Gate Valves give you longer life, cut maintenance costs, under these and other severe service conditions. Here's why:

Darling metallurgical engineers have thoroughly tested and standardized on the most highly corrosion-resistant aluminum alloys in use today.

Accurate casting control and precision assembly reduces friction and wear, provides maximum ease of operation.

Darling Double Disc Parallel Seat principle assures freedom from leakage, trouble and downtime.

Darling aluminum alloy valves are available in sizes from ½" through 24". Write us about your requirements and service conditions.

DARLING VALVES

DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

● **Shamrock Construction Co., Box 1177, Lansing, Michigan.**

Buckeye Pipe Line Co.—96 miles of 10-in. between Lima and Lebanon, Ohio. Field office: Urbana. Superintendent: Frank Parks.

● **Sharman, Allen, Gay & Taylor, Inc., Box 13152, Houston, Texas.**

Seadrift Pipeline Co.—a dual 6-in. from the vicinity of Seadrift, Texas, to the vicinity of Bay City. Headquarters: Port Lavaca. Superintendent: T. L. Beard.

Transcontinental Gas Pipe Line Corp.—to clear and grade two 14-mile sections in Alabama, with J. A. Adams supervising at Butler; and a 24-mile section near Jonesboro, Georgia, where field office is located and E. D. Singleton is superintendent.

● **Sheehan Pipe Line Construction Co., 514 National Bank of Tulsa Bldg., Tulsa, Oklahoma.**

Gulf Refining Co.—laying 23 miles of 10-in., taking up 20 miles of 10-in., and reconditioning 10 miles of 10-in. in Illinois. Field office: Carlyle. Superintendent: C. M. Brown.

Transwestern Pipeline Co.—a 600-mile gathering system of 4, 6, 8, and 10 in., in Oklahoma, Texas, and New Mexico.

● **Somerville-Illinois Co., Peoria, Illinois.**

Central Illinois Light Co.—70 miles of 24 and 30-in. Peoria loop line and Northern District transmission line. Superintendent: Frank Morris.

● **Stanley-Bledsoe Corp., 612 Daniel Bldg., Tulsa 3, Oklahoma.**

Pacific Gas Transmission Co.—double-jointing and yard-treating 466 miles of 36-in. pipe in three schedules in Klamath, Jefferson, Umatilla, and Gilliam counties, Oregon, and Walla Walla and Whitman counties, Washington. Superintendent: W. D. Smith, Jr.

● **Turriff-Burden, Ltd., Box 5216, Tulsa, Oklahoma.**

Iraq Petroleum Co. Ltd.—315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border, connecting Rumaila and Fao. W. T. Barker manages the project office in London, England. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Western Pipeline, Inc., 311 East 11th Street, Austin, Texas.**

Pacific Gas Transmission Company—468 miles of 36-in. from California-Oregon boundary to Rosalia, Washington, as joint venture with J. P. Neill and Company, Inc., Dallas, Texas. J. C. Oliver is project manager. Johnnie Wells is superintendent on a 150-mile segment between Malin and Bend, Oregon; and Ervin Simpson is superintendent on 150 miles between Bend and north of Ione, Oregon.

● **Williams Bros. Co., National Bank of Tulsa Bldg., Tulsa, Oklahoma.**

National Iranian Oil Co.—a 516 mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Meshed.

Alaska Pipeline Co.—74 land miles of 12-in. pipeline from the Kenai Unit gas field to Anchorage, Alaska.

Cia. Shell de Venezuela—expansion of its North Terminal system at Puerto Miranda and Cabimas on the northeast shore of Lake Maracaibo, Venezuela.

Calnev Pipe Line Company—230 miles of 8-in. products line from Las Vegas, Nevada, to Colton, California. Field office at Las Vegas, Harland Evens, superintendent.

PIPELINE PERSONALS

The appointment of P. A. Gass as president of Northern Natural Gas Company's new wholly-owned subsidiary, Northern Propane Gas Company, is announced. Gass also is senior vice president of the parent company. Other officers of the new subsidiary, who also are officers of Northern Natural include: **John Merriam,** chairman of the board; **H. H. Siert,** treasurer; and **B. H. Harper,** secretary. **R. K. Albon,** formerly vice president of marketing for National Propane Company of New York, has joined Northern Propane as vice president. Gass announces the purchase of Blaugas Company of Omaha and Cygas Corporation with facilities in Neligh, Nebraska, and Sargent Bluffs, Iowa. **George Vogl,** vice president of Blaugas for 14 years, will continue to manage the properties for Northern Propane and head up the Omaha division of the new company.

P. A. Gass

Don S. Willhelm has been named chief engineer of the wholly-owned subsidiary of Transcontinental Gas Pipe Line Corporation, Trans-Southern Pipeline Corporation, which will construct a $63,000,000 LPG pipeline from near Houston, Texas, to Danville, Virginia. Willhelm, a member of the Transco engineering staff for ten years, most recently was senior engineer in charge of special projects involving the operating departments.

Joining Bechtel Corporation as division engineer in Spokane, Washington, is **Charles R. Landers,** formerly division engineer for Gulf Interstate Company in Albuquerque, New Mexico.

Service Pipe Line Company's operation, maintenance and construction functions have been consolidated in a single department under Assistant General Manager **H. T. Chilton** and, as part of the reorganization, **A. M. Hill** has been promoted from line maintenance superintendent to the new post of technical supervisor of lines and **F. V. Cook** has been promoted from master mechanic to the new position of technical supervisor of stations. **R. M. Carter,** newly appointed to the position of lines and tanks supervisor, will report to Hill, as will **A. I. Zumwalt,** shop superintendent, and **F. W. Zilm,** contracting administrator. Under Cook's supervision are: **E. V. Grable,** machinery and buildings supervisor; **J. O. Holder,** electrical and communications supervisor; and **J. W. Foster,** mobile equipment supervisor. **A. S. Munneke,** superintendent for special electrical assignments, reports to Holder.

Boyd L. Sykes and **Bernard N. Barnes, Jr.,** have been appointed chief draftsman and assistant chief draftsman, respectively, in Lone Star Gas Company's transmission division. Sykes moves up from assistant chief draftsman to replace **F. E. Prudhomme** who has retired after serving with Lone Star for almost 29 years. Barnes was a sectional supervisor before assuming his new position.

Merry Christmas ✳ Happy New Year

standard pipeprotection inc.

3000 SOUTH BRENTWOOD BLVD. • ST. LOUIS 17, MO.

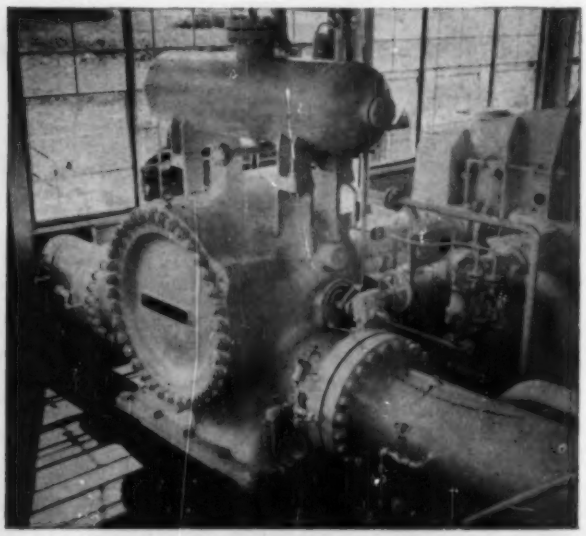
CENTRIFUGAL COMPRESSORS

DE LAVAL welded impeller permits higher horsepower, higher tip speeds, greater design flexibility

Now, with a single welded wheel, compressors rated up to 20,000 horsepower at 6500 rpm are giving excellent service.

Produced by a special welding process developed by De Laval, this new welded wheel construction permits higher tip speeds and fewer stages for a given pressure ratio.

Write for more information on this new welded impeller or contact your local De Laval representative.



Rated at 15,000 horsepower, this compressor, on stream for a prominent pipeline company, is capable of developing a pressure ratio of 1.56 in a single impeller, pumping 800 MMSCFD at an inlet pressure of 652 psia and an outlet pressure of 1020 psia.

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869 NOTTINGHAM WAY, TRENTON 2, N. J.

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FLEET-LINE

WELDING FITTINGS

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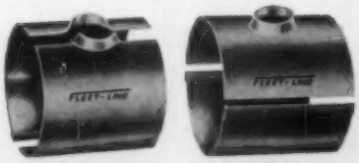
REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.

SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



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Dealers and Stocking Distributors throughout the United States and Canada.

All orders acknowledged by air mail or long distance telephone and filled at once.

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PIPELINE PARADE

. . . in equipment, services, sales

Mel Maddox has joined Allied Materials Corporation, Oklahoma City, as manager of the company's newly formed pipeline coatings and materials division, C. W. Barbour, president, announced. Maddox comes to Allied from 14 years' experience in the pipeline industry and related fields. His particular work has been with coal tar and asphalt pipeline coatings, epoxy and internal coatings, and the sales and service of pipeline wrap materials and equipment. Allied's new division grows out of 28 years' experience in the field of specialized asphalt and coal tar products. The division will be the only producer in the industry of both asphalt pipeline enamel and coal tar pipeline enamel, officials of the company say. Other major Allied Materials products include coal tar emulsions, and the polysulfide, polymer joint sealing compound, Allied Jet Seal. Main production center for the new pipeline products division is the Allied plant at Stroud, Oklahoma. Other company plants are located at Detroit, Michigan, and Los Angeles, California.

Mel Maddox

The Industrial Silencer Division of Burgess-Manning Company has promoted William A. Carroll Jr., from sales manager to manager of marketing to coordinate overall sales activities, including a newly-established international operation. Promoted from New York district sales manager to sales manager for domestic operations is R. T. Oliver Jr.

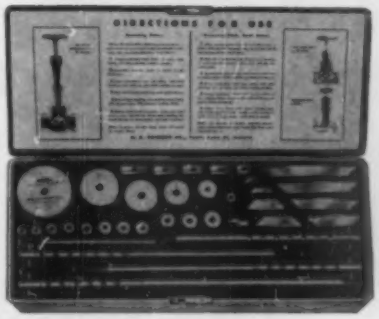
New representatives for Kraloy Plastic Pipe Company are: R. Q. (Dick) Swindler of Odessa, Texas, for west Texas and southeast New Mexico; E. E. Tedford of Shreveport, Louisiana, for east Texas, north Louisiana, Arkansas, and Mississippi; and J. R. Deaver Jr., of Lafayette, Louisiana, for south Louisiana.

Peter C. Reilly, president of Republic Creosoting and its subsidiary, Reilly Tar and Chemical Corporation, has been nominated for an honorary membership (active) in the Chemical Specialties Manufacturers Association. CSMA membership will vote on the nomination at a general meeting December 5 at Hollywood, Florida.

Roddy Sims, former design engineer for a large pipeline company, has joined **A. B. Chance Company** as sales representative for the petroleum equipment engineering and services division, Houston, Texas.

In a product diversification program move, Lone Star Steel Company has appointed George L. Flint as product development engineer to be officed at the company's Morris County, Texas, mill.

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

Reseats flat and tapered-seat globe or angle valves —all bibbs and faucets— in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50

FREE catalog showing our pipe repair clamps, saddles, and reseating tools

M. B. SKINNER CO.

SOUTH BEND 21, INDIANA

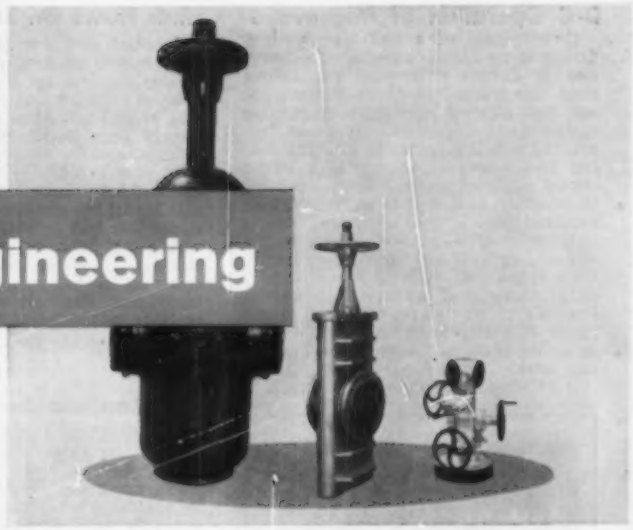
D-C Operation of Microwave

Finds Flaws On Buried Pipe

It's Now!

TOTAL Valve Engineering

NEW W-K-M COMPUTER PREDICTS PERFORMANCE



Left to right above, W-K-M's new: *Safe-T-Seal* Gate Valve (ASA); Pressure Sealing Gate Valve (ASA); Cross-type Triple Gate Valve (API).

Unique strain gauge analyzer pre-solves your valve problems

In *seconds* it gives answers that used to take *days*. This unusual digital logging computer developed to W-K-M engineering specifications finds out what will happen to a valve under every conceivable service stress.

The W-K-M computer measures strain, applies corrections for temperature, test material and gauge factors, and prints the results of its stress calculations. It can analyze 40 areas of a valve in less than 40 seconds!

Advanced research is an important part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. Another reason why W-K-M Valves perform better, last longer . . . on the world's toughest jobs.

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Pipeline

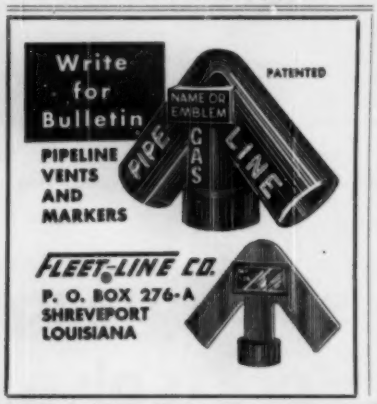
necessary, new manual gas-shielded metal-arc welding "MIGet" gun and controls

The improved design features a shorter, balanced ring gear-saddle assembly, mak-

D-C Operation of Microwave

Development of a new transistorized d-c converter enables complete d-c operation of Collins microwave and carrier from float charged 24/48-v batteries without any rotating machinery, protecting against outages from primary power failure and reducing noise. The 526Z-1 utilizes four power transistors in a bridge circuit in conjunction with a saturable transformer as a square wave switching oscillator. The stepped up square wave is rectified by a silicon diode bridge with a filtered output. The converter supplies 130 v d-c at 1.4 amp, drawing 8 amp at 24 v d-c or 4 amp at 48 v d-c. Output ripple is less than 0.1 mv with 0.4 mv average input ripple. Either 24 or 48 v d-c input may be accommodated by a simple strapping arrangement. *Collins Radio Co.*

Circle number (81) on reply card.



Finds Flaws On Buried Pipe

Supplied with a miniature, lightweight receiver with neck strap is a new buried holiday detector for locating very small flaws or "holidays" in protective wrap of pipe several feet deep, inspecting coating shortly after burial to reveal backfill damage, and for regular maintenance inspection to avoid leaks and reduce upkeep and cathodic protection costs. The portable Model 506 consists of a transistorized transmitter with an output meter, receiver with visual indicator, in addition to earphones, and search coil that doubles receiver for locating pipe and shorts between buried pipe. There are no vibrators, relays or other moving parts. *Pipetron Co.*

Circle number (82) on reply card.

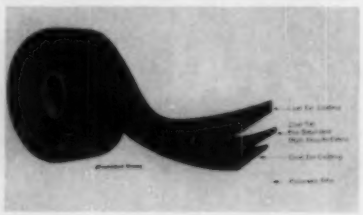
For Manifold Service

Equipped with a non-rising stem, a new regular port valve is said to be substantially smaller in overall height and width than conventional regular port valves—an advantage which makes it particularly suited for manifold service and other uses where compactness is an important consideration. The new G-6 incorporates the features of Grove's "Seal-O-Ring" design. Metal inner seat rings give a primary metal-to-metal seal backed up by "O" rings. With each operation, the metal seats strip foreign matter from the gate while the "O" rings squeegee and polish both faces. Always in contact with the gate, seating surfaces are isolated from corrosive and erosive elements in the line. No lubrication is required. *Grove Valve and Regulator Co.*

Circle number (83) on reply card.

It's New

Hot-Applied Coal Tar Tape



A new hot-applied coal tar protective coating in tape form, designed for single-thickness application following priming, consists of a high-tensile-strength fabric completely saturated with a coal tar pitch which provides a compatible base for the more pliable coal tar coating material on the tape. Tapecoat 20 is said to provide both coating and wrapping benefits. The tape includes a tough polyester film imbedded in the side of the tape not in contact with the pipe. Thus, when spiral wrapping is completed, the film becomes an outer wrap and provides extra reinforcement for protection against impact, soil stress and abrasive conditions, and serves as a separator in the roll. *Tapecoat Co.*

Circle number (84) on reply card.

Spy Detector

QUALITY SERVICE

is there . . . when you need it!

. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¾" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

Call, wire or write.

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Night Phone: HI 4-6745, EM 1-3824

It is with

Deep Regret

that we announce

the burial of multi-million dollar pipelines without insurance by a Pipetron Model 506 Buried Holiday Detector. Give your pipeline a decent burial, check your coating where it counts--in the ground! The Pipetron Detector pinpoints holidays, giving you both a visual and an audible indication. If you believe in life after burial, protect your investment by writing for the circular "You Can't Afford to Keep Buried Holidays a Secret."

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"Engineering Experience Into Products"

Sales territories available — inquiries invited.

Pipeline Equipment

Welding Gun, Controls

For use in light to heavy fabrication where numerous short welds, off-the-ground welding, or emergency repairs are necessary, new manual gas-shielded metal-arc welding "MIGet" gun and controls have been developed. The 2½-lb "Aircomatic MIGet" gun carries its own compact reel of wire, wire feeding drive rolls, and complete-range wire speed control, enabling the operator to weld as far as 50 ft away from the control panel which, in turn, can be placed 150 ft from the power source. The control, weighing less than 20 lb, is housed in a small NEMA cabinet with a carrying handle on top and cable and hose fitting on bottom and coordinates wire feed and welding current. *Air Reduction Sales Co.*

Circle number (85) on reply card.

Unaffected By Flashing

A new mass flowmeter designed to simplify measurement of LPG is said to be unaffected by the hazards of flashing because of its angular-momentum principle which eliminates any rotating parts that could be destroyed by the high velocities characteristic of flashing. Because it directly measures the mass of LPG flow, the device eliminates any need to correct for variations in temperature and fluid composition. Flow in pounds is continually totalized on a counter with an accuracy of ± 1%. *General Electric Co.*

Circle number (86) on reply card.

New Design of Cutting Beveling Machine

Announced is a newly designed line of pipe beveling machines — distinctive because it is said to feature the only improvement in design made on this type pipe beveling machine in the past 25 years. The improved design features a shorter, balanced ring gear-saddle assembly, making it possible to cut on shorter segments of pipe. The newly designed machine —

a compact, easier to use unit — reduces storage space by approximately one-half. The new design also has cut excessive weight from the machine, making it lightweight and easier and quicker to handle — a factor extremely important in larger models. In addition to the new features, the new Mathey pipe cutting and beveling machine retains the desirable features of past design. *C. A. Mathey Machine Works, Inc.*

Circle number (87) on reply card.

Pipeline Literature

Electrode Wall Chart . . . 23 in. by 35 in. . . . replete with welding symbols, welding arc, causes and cures of common welding troubles, typical deposition rates, a metal hardness conversion table, and description, number, color code, mechanical properties, size, current range, procedure and application information on the complete line of Hobart arc welding electrodes. *Hobart Brothers Co.*

Circle number (88) on reply card.

A 16 mm Film in full color and sound on "Fundamentals of Manual Shielded Arc-Welding Techniques" . . . adapted from General Electric's previously released six-film series, "Inside Arc-Welding." The first 22-min reel covers flat and horizontal arc-welding techniques. A second 23-min reel studies vertical and overhead arc-welding procedures. The film's primary purpose: operator training. *Air Reduction Sales Co.*

Circle number (89) on reply card.

Self-Teaching Manual . . . based on the international algebraic language . . . permitting engineers, mathematicians and scientists to program in universal mathematical language the general-purpose Bendix G-15 ALGO compiler. The 32-page manual illustrates with step-by-step examples the principles and operational characteristics of the compiler and includes a complete typical ALGO program. *Bendix Corp.*

Circle number (90) on reply card.

"How To Make Tractor Power Work Economically" . . . compiled by Caterpillar service engineers . . . answers such questions as: what is the thinking for economical operations, what constitutes overloading, what are the gains to be had from power shift transmissions, what is the proper way to use torque reserve. *Caterpillar Tractor Co.*

Circle number (91) on reply card.

"Are You In A Rut?" is the title of a brochure describing a new high flotation wheel development for off-highway transportation. "Hi-Flotation Wheel Kits" are for conventional vehicles and said to be interchangeable in minutes with regular wheels. *Terra Engineering Co., Inc.*

Circle number (92) on reply card.

WmSON "PIG-SIG II"

CAN BE INSTALLED OR REMOVED UNDER PRESSURE!

CUTAWAY VIEW OF PIPELINE

Gives visual or electrical indication of pig passage. Pig-Sig II with electrical indicator signals pump station operator or starts operation of automatic equipment. For other applications and complete details write for bulletin A-199.

Write Dept. B-2

T.D. Williamson, Inc.

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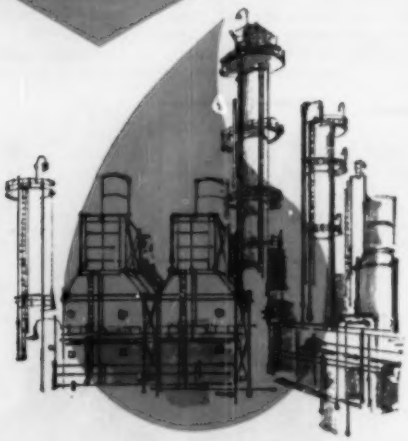
REPRESENTATIVES AROUND THE WORLD

a molecular coat with two-sided protection

UNICOR®

protects both product and equipment



UNICOR is a potent, film-forming, oil-soluble corrosion inhibitor that plates out on metal and protects your petroleum product from contamination and your equipment from corrosion.

Whether in pipelines, refinery vessels or tanks, UNICOR provides a sure and economical means of saving dollars through assured product quality and longer equipment life. Add only 10 to 20 parts of UNICOR per million of product for lasting protection against corrosion.

With UNICOR you will eliminate contamination, get longer equipment life, reduce downtime for maintenance and cleaning, and lower power costs. For information and samples write our Products Department.

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Correct selection and most effective use of corrosion inhibitors and other petroleum additives involves expert analysis and consideration of many factors. As specialists for over a quarter-century, UOP is able to provide unparalleled field service, brought to you by a member of our staff of *Product Sales Engineers. For detailed information on the UOP family of superior inhibitors and additives call or write our Products Department.

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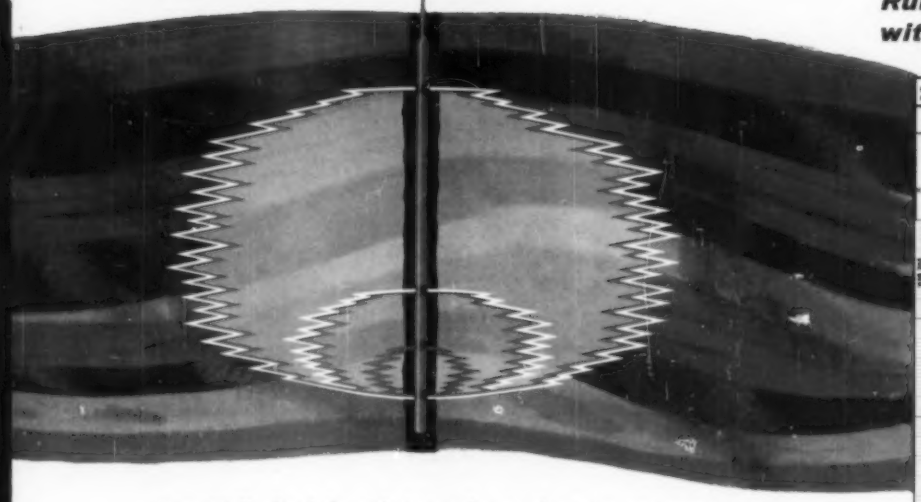
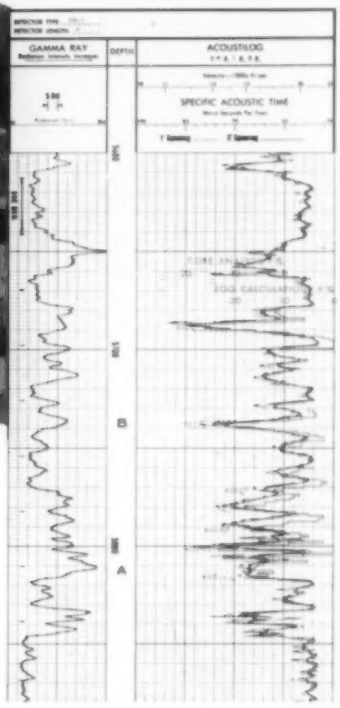
WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

Another FIRST by LANE-WELLS

DUAL SPACED ACOUSTILOG*

Run SIMULTANEOUSLY with Gamma Ray or SP





Lane-Wells Dual Spaced Acoustilog is the most accurate, most meaningful, most informative, quickest run log of this type available anywhere. All new instruments, offered exclusively by Lane-Wells, make it possible to run both 1′ and 3′ spacing curves plus either a self potential or a gamma ray curve all on one trip into the well.

Provides Most Meaningful, Most Accurate FORMATION EVALUATION

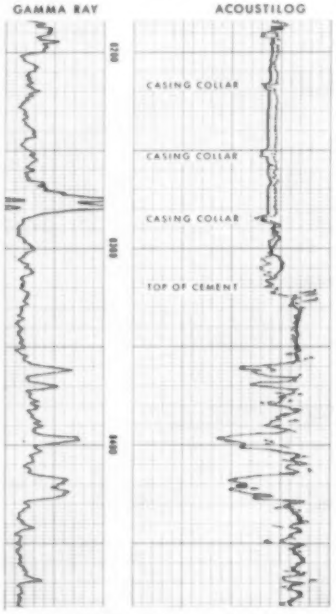
MOST MEANINGFUL!—Because both the 1′ and 3′ curves are recorded while the instrument is in the same position in the borehole, the differences in readings are significant and reliable. Porosities may be read accurately directly from the log. **MOST ACCURATE!** — Exclusive design and circuitry features of Lane-Wells Dual Spaced Acoustilog enable it to measure sound velocities within ±2% of known formation velocities.

PLUS – CEMENT LOCATION

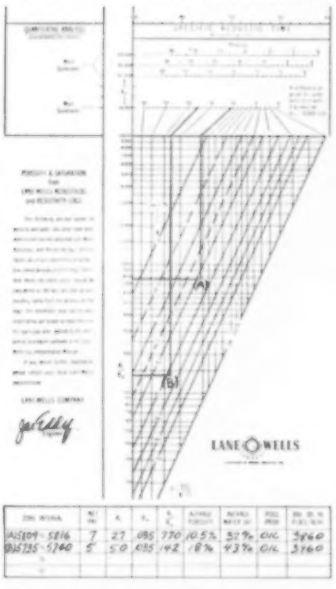
Dual Spaced ACOUSTILOGS have proved remarkably valuable in locating cement and channeling behind casing. Even in areas where other cement locating equipment fails, Acoustilog gets the information.

For complete information about how the all new Dual Spaced Acoustilog can save you money and give you more information about your well, call your nearest Lane-Wells office or write P. O. Box 1407, Houston 1, Texas.

*Lane-Wells Service Mark



Acoustilog used to locate cement.



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